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ART. XI.—*Historical Notes on the Systems of Weather Telegraphy, and especially their Development in the United States;* by CLEVELAND ABBE, A.M.

THE recent establishment in our own country of a national System of Weather Reports and the general interest in this enterprise, has induced me to accede to the request of the Editor of this Journal, and to offer the following notes relating to the development of the idea of storm warnings.

It was evidently possible to study with advantage, the progress of atmospheric changes only when the telegraph lines had become widely extended over the earth's surface. It was through the public press—the daily newspaper—that it first became possible to watch the hourly progress of storms, under one's own eye, and to confirm the general laws independently deduced from the closet studies of the professional meteorologist. The first mention that I find of the systematic daily use of these daily press reports, is given by Kämtz, in his "Repertorium," wherein it appears that already in 1835, he began to collate the weather reports published in the Vossische Zeitung of Berlin. In the subsequent history of Weather Telegraphy in Europe, I first find a suggestion by John Bell, made in 1848, at the Swansea meeting of the British Association for the Advancement of Science, that in London it was already possible to receive weather reports with only a few hours' delay, from most parts of Great Britain and Europe, and that this information ought to be utilized for the study and prediction of storms. The general press reports seem to have continued to be in

Europe the only source of information regarding the impending weather, until Le Verrier first began to publish the Bulletin International. Already in 1854 he had urged the importance of systematic telegraphic weather reports, and in 1855 the Emperor Napoleon sanctioned the beginning of the undertaking: the stations from which reports were received during the first two years were confined mainly to France, but the network of stations was extended to foreign countries in 1857. In 1858 all the important cities of Europe were included, and on the 1st of January of this year began the publication of the "Bulletin International,"—previous to this the telegraphic reports had been distributed gratuitously, but only to the observers and others immediately engaged in the work. With September, 1863, began the publication in the Bulletin of the chart and the isobaric curves for Europe. During the previous six years LeVerrier had met with insurmountable obstacles to the systematic utilization of the weather reports, by disseminating predictions of storms, &c.,—but occasional warnings had been issued, and the practicability and importance of the matter had been faithfully urged by him. In this year (1863) stimulated probably by the success of Fitzroy in England, the obstacles were partly removed, and the French system of daily probabilities of weather was inaugurated. In 1865 the coöperation of the French marine was obtained, and with this year begins the series of quarterly volumes of the "Atlas Généraux des Mouvemens de l'Atmosphère." To the preface of this vol ume we must refer for the fullest detail of LeVerrier's undertakings.

The storm warnings issued since 1860 by Buys Ballot in the Netherlands, and those of Fitzroy (died, May, 1865), and Babington in England (Feb., 1861, to Dec., 1865), followed upon the growing success of the French system; and the recent extension of these to India and Russia, as well as the system now being organized in Australia, need but to be mentioned. The present English system in charge of the "Meteorological Committee," is in some respects very different from that established by Fitzroy: it began its publication of weather intelligence in December, 1867.

While thus practical meteorology has made brilliant progress in Europe, we cannot forget that the original impulse to this success was given by the labors of our own countrymen. Franklin* is said to have been the first who strictly defined and published the general law that the storms of our Southern States move off to the northeastward over the Middle and

* Earlier than Franklin must have been Lewis Evans, who, according to Hon. T. Pownal, M. P., published in 1749 at Philadelphia, the brief statement of this general law. (See Blodget's Climatology, p. 379).

Eastern States, preceded by northeastern wind and rain, and these latter followed necessarily by low barometer and westerly winds, with clearing up weather. In this we recognize the original of the generalizations of President Jefferson and Dr. Mitchell, as published in their writings, and something a step in advance of the propositions of Lavoisier, for the study and prediction of storms. (See Atlas Généraux, 1865, p. 13).

To Sir Wm. Reid and W. C. Redfield, (this Journal, 1831) is due a clear analysis of the elements of storms and the deduction of the more general laws followed by them. To the generalizations of these authors relative to the ocean storms of the Western Atlantic, Espy (Philosophy of Storms, 1841, and Reports, 1854), and Loomis (on the Storms of 1836, 1842, &c.) added others referring to the storms of our interior, and to the origin of atmospheric disturbances. To Ferrel (the Motions of Fluids and Solids, 1856 and 1860) we owe the most complete mathematical investigations into the general and the special movements of the atmosphere.*

However frequently the idea may have been suggested of utilizing our knowledge by the employment of the electric telegraph, it is to Professor Henry and his assistants in the Smithsonian Institution that the credit is due of having first actually realized this suggestion.†

The practical utilization of the results of scientific study is well known to have been in general greatly furthered by the labors of this noble Institution, and from the very beginning Professor Henry has successfully advocated the feasibility of telegraphic storm warnings. The agitation of this subject in the United States during the years 1830–1855, may be safely presumed to have stimulated the subsequent action of the European meteorologists. It will be interesting to trace the gradual realization of the earlier suggestions of Redfield and Loomis, in the following extracts from the annual Smithsonian Reports of the respective years.

* Meteorological studies were actively carried on by the Joint Committee of the American Phil. Soc. and of the Franklin Institute, from 1834 to 1838, Professor Espy being chairman, and were furthered by the Franklin Kite Club in the latter year.

† See Vienna Acad. Sitzungsberichte.

The first published suggestion that I have found is by the lamented Redfield; this Journal, Sept. 1846.

"In the Atlantic ports, the approach of a gale may be made known by means of the electric telegraph, which probably will soon extend from Maine to the Mississippi, &c."

The next notice and very nearly in the wording of the above, is in the Report to Prof. Henry, by Prof. Loomis. Smithsonian Report, 1847.

"When the magnetic telegraph is extended from New York to New Orleans and St. Louis, it may be made subservient to the protection of our commerce, even in the present imperfect state of our knowledge of storms, &c."

See also the "Rural New Yorker" of the following year; also the "Boston Courier" and the "Philadelphia Evening City Item," for 1848 and 1849.

1847. "The extended lines of telegraph will furnish a ready means of warning the more northern and eastern observers to be on the watch for the first appearance of an advancing storm."

1848. "As a part of the system of meteorology, it is proposed to employ, as far as our funds will permit, the magnetic telegraph in the investigation of atmospherical phenomena.... The advantage to agriculture and commerce to be derived from a knowledge of the approach of a storm by means of the telegraph, has been frequently referred to of late in the public journals; and this we think is a subject deserving the attention of the Government."

1849. "Successful applications have been made to the presidents of a number of telegraph lines to allow us at a certain period of the day the use of the wires for the transmission of meteorological intelligence . . . . . as soon as they [certain instruments, &c.,] are completed, the transmission of observations will commence."

[It was contemplated to constitute the telegraph operators the observers].

1850. "This map [an outline wall map] is intended to be used for presenting the successive phases of the sky over the whole country at different points of time, as far as reported."

1851. "Since the date of the last report the system particularly intended to investigate the nature of American storms immediately under the care of the Institution, has been continued and improved."

The system of weather reports thus inaugurated continued in regular operation until 1861, when the disturbed condition of the country rendered impossible its further continuance. Meanwhile however the study of these daily morning reports had led to such a knowledge of the progress of our storms, that in the Report for 1857, Prof. Henry writes:

1857. "We are indebted to the National Telegraph Line for a series of observations from New Orleans to New York and as far westward as Cincinnati, which have been published in the Evening Star of this city. We hope in the course of another year to make such an arrangement with the telegraph lines as to be able to give warnings on the eastern coast of the approach of storms, since the investigations which have been made at the Institution fully indicate the fact that as a general rule the storms of our latitude pursue a definite course."

It would seem therefore that nothing but the disturbances of the late war prevented our having had ten years ago a valuable system of practical storm warnings. Even before peace had been proclaimed, Professor Henry sought to revive the systematic daily weather reports, and in August, 1864, at the meeting of the North American Telegraph Association (see their published

Report of Proceedings), a paper was presented by Professor Baird, on behalf of the Smithsonian Institution, requesting the privilege of the use of the telegraph lines, and more especially in order to enable Professor Henry "to resume and extend the Weather Bulletin, and to give warning of important atmospheric changes to our seaboard." In response to this communication it was resolved, "That this Association recommend . . . . . to pass free of charge, . . . brief meteorological reports, . . . for the use and benefit of the Institution."

On the communication of this generous response, preparations were at once made for the laborious undertaking, and the inauguration of the enterprise was fixed for the year 1865. In January of that year however occurred the disastrous fire which so seriously embarrassed the labors of the Smithsonian Institution for several following years: it became necessary to indefinitely postpone this meteorological work, which indeed had through its whole history been carried on with most limited financial means, and was quite dependent upon the liberal coöperation of the different telegraph companies.

It will thus be seen that without material aid from the Government, but through the enlightened policy of the telegraph companies, and with the assistance of the munificent bequest of James Smithson, "for the increase and diffusion of knowledge," the Smithsonian Institution, first in the world, organized a comprehensive system of telegraphic meteorology, and has thus given first to Europe and Asia, and now to the United States, that most beneficent national application of modern science, the Storm Warnings.

Having been absent from the United States in 1864–66, it so happened that I was not acquainted with the more recent plans of the Secretary of the Smithsonian as above detailed, but rather supposed that its costliness would always prevent the resumption by that Institution of this national work. In May, 1868, on taking charge of the Cincinnati Observatory, I urged in my Inaugural Report, that the practical utilization of the sciences there cultivated should be our constant care, and the desirability of storm warnings was specially indicated. This latter subject was in the same year brought by myself before the Cincinnati Chamber of Commerce, and that body at once decided to authorize me to establish a system of Reports and Predictions, at its own expense and for its special benefit.

"The Weather Bulletin of the Cincinnati Observatory" began September 1st, 1869, the previous summer having been fully occupied with preparations for this duty as well as with the labors incident to the "eclipse expedition" of the Observatory.*

* Accompanied by seven amateur assistants, I occupied the site of old Fort Dakotah, (now Sioux Falls City), Dakotah Territory. A very complete series of

Beginning with ten stations, the number was gradually increased to thirty, from most of which the experienced correspondents of the Smithsonian Institution sent me their morning observations. The dispatches being in a condensed form, allowed me to receive the fullest details, i. e. barometer; dry and wet thermometer; direction and force of wind; weather and rain-fall; kind, amount, direction and velocity of motion of the upper and the lower clouds; and remarks. The Bulletin was published in printed form at first, and subsequently by the "Rogers Manifold Bulletin Process," appearing daily (Sundays excepted), at noon. To it was appended a brief forecast of the weather that would probably be experienced at Cincinnati during the next twenty-four hours.

This was, I believe, the first systematic attempt in the United States to make the weather reports practically useful to our commercial communities. At the expiration of the first three months' trial, and while negotiations were pending with the Western Union Telegraph Company, for its permanent continuance, I, in order to prevent a break in the series, for six months maintained the Bulletin myself, receiving the dispatches gratuitously from the telegraph employées, and publishing the reports daily, including Sundays, in the newspapers of Cincinnati. The reports indeed ceased to include barometric readings, but the number of stations was much increased, and the value of the Bulletin to the general public very frequently acknowledged. In February, 1870, Mr. Armstrong, the enterprising manager of the W. U. Tel. Office in Cincinnati, undertook the daily publication (by the Rogers Manifold Map Process) of a Weather Map for the United States, and this added very much to the value of and interest in the reports. Copies of this map were regularly sent to the telegraph offices in Chicago and New York and elsewhere, everywhere meeting with favor. In May, 1870, the publication of both Bulletin and Map was undertaken by Mr. Armstrong, and continued to be issued by him until in December, when the entire service was relinquished, in view of the daily publications of the Army Signal Office.

I had undertaken this laborious work, in the confident hope that by it a local interest would be excited in the Observatory, which might possibly lead to its being better supported by the friends of science in Cincinnati: and equally had I hoped and expected thus to contribute towards the establishment

observations was secured, but the subsequent year was incessantly occupied with very imperative labors on the Weather Bulletin and a subsequent absence from Cincinnati, so that I have as yet been utterly unable to even attempt the reduction and publication of our observations. By means of a very fine six-inch achromatic and favored by a remarkably clear atmosphere, interesting and novel observations were made upon the corona, of which a brief notice was at once communicated to the editor of the *Astronomische Nachrichten*.

of a more extended and ultimately of a national system, such as those that had long been known in Europe. To this end I, in August, 1869, in behalf of the Cincinnati Chamber of Commerce, had proposed to the Board of Trade of Chicago a general plan of coöperation by which both organizations would share in the advantages expected to result from the Weather Bulletin. That body, however, through a special committee, preferred not to engage in such an enterprise, although sensible of its feasibility, unless the Dearborn Observatory should give it the weight of its authority and name; but the other duties of Professor Safford seemed to forbid this, and I was forced to forego the advantage of such coöperation. An editorial in the Chicago Evening Journal of August 13–17, served, however, to call attention to the Cincinnati enterprise.

In November, 1869, occurred at Richmond the annual meeting of the National Board of Trade. Several of the Cincinnati delegates (and especially Mr. John A. Gano, President of the Cincinnati Chamber of Commerce) had been the hearty supporters of my Weather Bulletin, and were desirous of bringing the subject to the attention of that body. Their action was, however, anticipated by that of the Hon. C. D. Holton of Milwaukee, who presented a memorial, drawn up by the Hon. I. A. Lapham. This distinguished observer, to whom I had for some time been indebted for my daily weather report from Milwaukee, was perhaps more sanguine than myself of the prospect of immediate aid from Congress, and heartily labored to impress the importance and feasibility of storm warnings upon the attention of that body. By him was drawn up the memorial presented to Congress, Dec. 14, 1869, by Hon. H. C. Paine, and the subsequent papers printed as Miscellaneous Document 10, (41st Congress). This latter paper, as well as the chart of the storm of March, 1859, published by Professor Lapham in the Chicago Bureau, served to very generally arouse public attention. The necessity for action was heartily endorsed by prominent Boards of Trade and Commerce and by eminent scientific authorities. To Mr. Paine is due the suggestion that the conduct of the service be entrusted to the War Department, and it is interesting to notice that independently of and coincident with the labors of Professor Lapham, "papers and maps in reference to the same subject were prepared in the War Department."

Congress as well as the country seemed ready for this measure, and by unanimous consent the following joint resolution was promptly passed, receiving the President's signature on the 9th February, 1870:

"Be it resolved, &c., That the Secretary of War be, and he hereby is, authorized and required to provide for taking meteorological observations at the military stations in the interior of

the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern Lakes and on the sea coast by magnetic telegraph and marine signals, of the approach and force of storms."

By a general order of March 15th, Brevet Brig. Gen. Albert J. Myer, the Chief Signal Officer of the army, was charged with the duty of the execution of the preceding law, and has therefore organized in connection with the Army Signal Office, the "Division of Telegrams and Reports for the Benefit of Commerce."

Washington, May 1, 1871.

ART. XII.—*Infusorial Circuit of Generations;* by THEOD. C. HILGARD.

[Continued from page 25.]

A DIRECT *onward* evolution of Vorticella I had occasion to realize on the fetid scum cuticle of a putrescent aquarium. All the Vorticellæ which, in dense clusters, lined the under surface of that membrane, or animal pellicle, were found to *elongate* into a sort of roughish, but very hyaline, cucumber-shaped form; each "cucumber" at first crowned with a true vorticellan pitcher-mouth, mostly, however, closed and rounded over, occasionally gaping or as it were *yawning* spasmodically, at intervals only, and which finally "shut up" for good. The little glassy knobs—like so many trunk-nails—that covered the surface, grow into soft, jerking-bristles:* the mouth into the well-known mustachioed slit of barbiform *cilia;* and the wan, limpid, empty and now entirely flattened, ligulate or sandal-shaped body tears loose as a young fluttering, pallescent *Oxytricha* (*Pelionella*), or so-called "hackle-animalcule:" *darting* by the jerks of its stiffish marginal bristles, and by the constant "plying" of the long-barbed, ciliate slit effecting its slower progress. It never revolves, but often crawls; (both in contradistinction to the fleeced, revolving and vacuole-propelled "Paramecium" form.

This is probably the "short-line" development, of Oxytricha, directly from the germinal clouds or the parasite of *Chlamydococcus*, through Vorticella. I have no good figures to refer to, since even the detailed ones of Ehrenberg, in Trans. Berlin Acad.

* In their onward development these softish bristles are indurated into "styles" (of specialists). The attentive reader will observe that on such alterations of growth alone, a great many colliding false genera and species have been formed. *Sap. sat.* We have naturally to reject all, of which the *mode* of development remains unknown, as indicating a false standpoint.

Sc., 1833, Tab. III, figs. II, III, and IV, which belong here (as well as Tab. XXIV and XXV of A. Pritchard's Hist. Inf., 1861), are too inaccurate to serve as a guide, or to be readily identifiable even by those acquainted with the real, natural object-material itself.

At first the bristles of the (tongue-shaped, flat and elongate-elliptical) Oxytricha are fluttering and tremulous; but as it feeds and rapidly increases in bulk, all the well-known characters of the complete "Oxytricha," its stiffish darting-bristles, its grumose, obscured body, irregularly replete with granular yolks, and very frequently cross-dividing, become typified. When thus cross-divided (a process well-known and abundantly figured) the front part alone retains the barbed mouth, which, from the apex, switches down like a moustache on a longitudinal slit about a quarter of the whole length. The blunt rear-part, on the contrary, separates with an incurrent angle which soon contracts into a new mouth; whereby the rear-animal takes a blunter shape (like the cotyledon of an almond, the flat side downward).

The Oxytricha is by no means, however, to be considered as an adult form, since it is never seen to exhibit a continuity as of a membrane, or of internal ducts or viscera. Neither is it seen to "copulate" or adhere lengthwise, or in any other fashion, to one another, except in the process of self-division. Nor does it readily divide by longitudinal fission, in this state. I have seen this only once. Crawling and darting by an apparatus of marginal bristles, prolonged in front and particularly in the rear, it is destitute of the "propulsive vacuoles," as found e. g. in the large "*Paramecium Aurelia*;" but, besides being studded, particularly in the rear portion, with a great number of larger and smaller granular *pellets*, its body exhibits near the middle a large, clear and granulate "germinal speck" or *nucleus*, which is often observed to swell, protruding globularly over the surface, below and above, when seen crawling, in profile.*

Occasionally it is seen to extrude, suddenly, that turgid germinal nucleus or yolk (*vitellus*), which, as in all these cases, is itself coatless, but hung around with divers jerking molecular fragments, torn loose from the parental body;—which is *ruptured on the spot*, but readily "re-cemented," as it were.

* The transformation of the "rear-part" of Oxytricha, as given by J. Haime in Ann. Sci. Nat., Ser. 3, tom. xix, p. 109 (and represented in Carp. Micr,. p. 447 and 448), I have not been able to verify myself; it must not, however, by any means be confounded with the *encystments* (1) of Vorticella, producing wafer-like molecules; (2) of the non-pulsating, tear-shaped "Paramecium kolpoda" grub, producing free Oxytricha; nor (3) with that of the "oyster" or "porte-monnaie" grub, producing paramecium-like bodies, gregarina-fashion; nor either (4), with some large Oxytricha "currants," containing the revolving "crucible."

The larger of these coatless, granular yolks—(constituting the original *pseudo*-genus, and species "*Zooglœa Termo*" Dujard.")* mostly consist of two parts, viz: a general "albumen" of a granular and evidently *trabecular* texture, enclosing one or two *distinctly coated*, quite hyaline and perfectly *globular vesicles*. The latter resemble in shape a very clear white currant, as it were, by having a sharply defined circlet inscribed near one side, that is caused by a local *inversion* of contents (somewhat like the air-vesicle within a hen's egg).

These "currant"-yolks enlarge in size and soon at the (darkening) circlet, or rim of the introversion, reveal a rapid rotation and "ciliary motion;"—and, still later, a contortion and volubility of contents, really perplexing to the attentive beholder, who in vain attempts to determine its form, or at least to detect it in the moment of hatching, "anxiously wasting whole nights and half days" thereon, as Ehrenberg has expressed himself on a similar subject. At last the membrane bursts and extrudes a globe or halo of gelatine, containing a crucible-shaped body, gently moving, which, when finally set free by the rupture of that gelatinous halo, at once elastically *extruding the inverted part*, takes a shape resembling a rice-palea or the fore-wing of a thunder-fly (Thrips); traveling broad-end foremost with great velocity, and steady as an arrow. After a while a somewhat ludicrous scene ensues, when the little animal, by shedding its fissured skin or scabbard, is seen violently struggling to disentangle its large jerking bristles hidden in the *veins* of the sheath, and its small body. It thus appears like a little dwarf, frantically floundering about in a Spanish cloak, spurs and sword too large for their owner. It now represents a very small Oxytricha with comparatively very long, stout, but as yet softish bristles.

This formed the more *direct* evolution, from the Oxytricha pellet, viz: out of its circular "currant-vesicles." Its enveloping grumose mass of "trabeculated albumen," however, keeps still increasing to the appearance of a loose snow-ball, as it were; and each single trabecular joint assuming a sort of warped §-form, and a jerking spasmodic commotion, they at last tear loose singly, and escape each as a lanceolate, *warped* and finely-tailed "*Vibrio Termo* Dujard."† In consequence of its twisted

* As represented by Cohn in "Nov. Act. Nat. Curios." 1854, Vol. I, Tab. xv, fig. ix. In Klob's microscopic researches on Cholera, the term is misapplied to engorged joints of dissected corruptive fibrils (or, "Oidium lactis") replete with bacterial daughter-cells.

† The name of "*termo*" (τερμων, a boundary-pole or stake) probably referred originally, rather to the cylindric "battering-rams," extruded from diffluent "currant"-vesicles (or *amœba*) of the paramecian cloud-dissolution, as below detailed. The albuminous Oxytricha-pellet is pretty well represented in A. Pritchard's "A History of Infusoria," tab. xviii, fig. 69. The indistinct §-shaped (constituent or) developing particles, however, are there technically represented by shading with cross-striæ, conveying a false impression of their shape and structure.

shape, it makes its way with a vacillating archimedean motion, being constantly turned round as it is rushing onward. When about $\frac{1}{8}\frac{1}{0}\frac{1}{0}$ line long, it already clearly reveals the (still warped, but finally flat) *wafer*-shaped body; and the longitudinal *striæ*, *fringed with an undulating fleece*, as well as the oblique, ciliate mouth, which also characterize its later stages. From an oblong orbicular pouch-shape, when about $\frac{1}{8}\frac{1}{0}$ of a line, it becomes round like "navy"-beans (up to $\frac{1}{5}\frac{1}{0}$ of a line) only a little tapering at the upper end; the small oblique mouth being a little above the middle. The delicate longitudinal striæ all over the body—melon-fashion—give them an iridescent appearance, both under the microscope, singly, and when swarming in masses on the surface, e. g. of aquaria, or of the draining-pans of flower-stands. The striæ are apparently set with very soft *undulating threads*, resembling wool, nearly half a diameter long, in likeness of "ginned" cotton-seed. This feature is absolutely overlooked in most of the figures from Ehrenberg up to the present day; otherwise, the former's "*Paramecium Kolpoda*"* would seem to represent a few of its onward developments.

The body now commences to *bisect*, at first crosswise; becoming *waisted, across the mouth*, so that each half has a part of the old one. After assuming the form of an 8, they, after long struggling and toiling, bisect, often spinning out a long gelatinous thread (as of a limpid gum) and jerking each other most lustily; but after disruption, they presently round off.

In this condition, and the following, the bodies contain one larger and a great many smaller granular *pellets*,—"yolks" or "germinal specks," which I have not distinctly seen discharged. But now the surface of the water becomes clouded with such granular balls, of uniform molecules (about $\frac{1}{1}\frac{1}{2}\frac{1}{0}\frac{1}{0}$ line in thickness) that likewise germinate into the fragiform clouds, alluded to in connection with Vorticella, etc., and is covered with an apparently amorphous, most delicate but cohesive pellicle (as of collodion) at the superficial contact with air. All these forms, as above stated, when caught on a dry surface (e. g. by their undulating floss), instead of forming into a dry scab, suddenly become *liquid* (like fusing lead), with an immense internal commotion of parts, and bodily dissolve into such cloud-molecules. The "wool" itself becomes *quasi*-"dropsical," and each single fibril diffluent into a series of such uniform globular molecules, which at first are endowed with an independent motion, vibrio-like. Besides this, most of the encystments, moultings and yolk-extrusions take place under the isolating cover of that uniform protoplasm-membrane, which seems to exhale a sort of bituminous odor (like the fumes of burning flesh, sun-baked carrion, or the rank smell of miry river banks). Membranes, as

* Abhandl. Berlin Acad. Wiss., 1834, Tab. III, fig. 3.

thin but chemically homogeneous organic substances being impermeable to certain gases, while permeable to others, a good deal of physiological interest is involved in the study of this protoplasm-membrane, and its relation to the swamp-gases. The particles of the nubecula are uniformly globular.

After repeated *cross*-segmentations, these undulate fimbriate bodies, always revolving about the long axis (while evidently traveling onward by the action of the *ciliate mouth*) divide *lengthwise*, from below upward; thereby becoming somewhat purse or tear-shaped; the mouth being split in two, so that both stand "plying" mouth-to-mouth, while yet connected at their foreheads, as it were. These finally tear asunder by indentures, after which each has the shape of a crooked glass-tear. When more adult, and about $\frac{1}{4}\frac{1}{8}$ of a line long, the internal yolks and designs have disappeared; the sarcode assumes a uniform yellowish tinge; its mouth forms deep cavities, while its front is toppling over like the hood of an Indian turnip (*Arum triphyllum*) or of a Sarracenia leaf. It now contracts to a globe and encysts. When a smooth, transparent crust is formed, gradually an inward gyration of cilia (as of an enclosed centipede) which ultimately becomes very violent, is observable; and at last the excessive fatigue of watching this tantalizing gyration may be rewarded by seeing the *inmate emerge*, either as quite a large but excessively limber, fluttering and transparent, full-size, single Oxytricha; or else several smaller, mostly narrow, triangular slips)* escape, with the same exceedingly restless volubility; the marginal bristles not yet being stiffly extended in a plane, but ruffled up and down like the bristles on the undulating borders of a thistle-leaf. As they feed and the tissues become scatent, the entire form of an Oxytricha is presently acquired.

I have observed still another development of Oxytricha; its first source, however, being as yet unknown to me. There appear on the field of action numbers of quaint-looking, big-eyed balls, about $\frac{1}{1}\frac{1}{0}\frac{1}{0}$ line thick, snouted, as it were, with a sort of "hair-lip" resembling a duck's bill; the stiff bristles within the bill-shaped mouth quivering with a sort of expressive smirk, and looking altogether odd.

They come full-sized and booming upon the stage, and in this respect argue a direct derivation from certain haw-shaped, five-costate vorticellan buds, with a contracted *pappus* of stiffened cilia around the orifice, spinning and rebounding like humming-tops. The "goggle" now soon becomes stationary, and shortly after, rapidly expanding, and its germinal speck or nucleus (the "eye") particularly enlarging, within half an hour

* The figures L and M, p. 447, in Carp. "Micr." seem to belong here.

it dropsically flattens out into a pretty well-sized Oxytricha,* by a similar sort of internal fluxile commotion of particles as when the animals dissolve into molecular "sauce."

But Oxytricha is not a perfect animal. It has no membranes, and evidently no fibrous tissues at all. The entire texture apparently remains in an embryonic, *vitelline* condition, as yet.

I have in a single instance witnessed what appeared to be the *moulting* of a perfect Oxytricha. The front border was somewhat removed from the body, which it crowned like the crest of an ancient helmet, and within each rigid bristle ("style") *as within the fingers of a glove*, was contained the far more delicate corresponding one of a clear (and now entirely yolk-less-bodied) animal,—the lower quarter being in a like manner hidden in a part of the old coat. I thought it was plainly identical with the following animal, whose development brings us up to "*Paramecium Aurelia.*" As I have not been able to chance upon such a moulting process again, I reserve the decision.

A clear (internal) animal is apparently developed by this moulting of the Oxytricha. Of the latter, the very bristles, when detached, seem to possess individual vitality, singly beating about for quite a while, and even empty coats (apparently *shed*) sometimes behave as if they had a life of their own. At all events, at a certain epoch there appears at once the next form in question,† in full size, upon the field; the transparently clear bodies sometimes showing a scalloped border, and alveoli, as of *former* yolks, *extruded*—that soon smooth over. In outline, the animal appears somewhat like the soft parts of an oyster, being flat, somewhat lop-sided, in the shape of a human ear—tip foremost. It is "doubled up" at the straight border, the broader lower rim being overlapped, *as by a lid*, with a smaller, but thicker, upper flap ("lorica") containing one clear germinal speck. This animal *opens like a book*, undoubling its flaps; and it is thus that it devours its prey (such as conferval spawns, etc.), by bodily enveloping them like a ray-fish (*Raya*) enfolding the nourishment as if *fused around it*, and the whole surface exhibiting an incredibly rapid ciliary commotion *during the whole process of digestion.* This done the cloak again unfolds, often appearing like two stipules, e. g. of a *Liriodendron*, and then closes up again. On drying up, or in search for air and *moisture*, the animals are often seen to mutually enfold each other's flaps. This cannot, however, be interpreted as a sexual

* This somewhat resembles fig. F, turning, by fluid expansion, into fig. E, (Carp. Micr., *ibid*). Fig. F, however, requiring to be duck-billed, as it were, and fig. E to be lop-sided and the nucleus more central.

† Perhaps the "*Euplotes*" of authors. Their descriptions and figures, however, offer nothing that sufficiently resembles this very common form, so as to be readily identifiable.

copulation, seeing that in the first place they neither develop any eggs; nor, in the second place, do they even extrude yolks; but their onward development is *by encystment.*

Within a few minutes such a full-grown "oyster-grub" is seen contracting its big flap, so as to present the shape of a hat with a warped rim and hemispherical crown, the latter formed by the blunter lobe, which contains the "speck" or "eye," and, contracting, gets hemispherically rounded. Very soon (with a constant adjustive quivering of the cilia-like bristles) the whole is rounded into a globe, wherein the doubled inside forms a ciliate hiatus. The latter, soon contracting, closes over. Nothing is now seen but a ball with a clear "germinal speck." In a few hours a *double* contour (the outer one granular is exuded. The speck or "eye" itself now becomes dusky and granular. It increases. It bisects "Gregarina-" fashion. Each pear-shaped segment again acquires a clear speck or "eye." They elongate, being connected by the blunt ends,—each one tapering to a very soft apex; and these very large germs or pseudo-Gregarinas at last become liberated, probably as "*Paramecium Aurelia,*" which now appears *full-grown* on the scene.*

It is about the length of the Oxytricha, about three times the length of the revolving wool-fringed grubs of the Oxytricha, and by all means more complexly organized than either. It has the shape of the (shoemaker's) *last* for a very elegant ladies' shoe. From one side it therefore gives the figure as of a foot-print (without the toes); but viewed on edge has a pointed rear end, and in this profile it "takes the name" of Paramecium *caudatum!* The ankle of that "last," however, is beveled away leaving the instep a ridge. Its oral aperture, not clearly distinguishable, is in the middle, slanting almost longitudinally for about one quarter of the length of the body. It seems to work its way, dashing by vacuole-contraction, while at the same time revolving by a roundabout coat or film of short pubescence, almost too delicate to be made distinct. In what appears to be the abdomen it has the well-known circular *pulsatory vesicle,* wherewith it propels itself, and around which point it is often seen spinning like a wheel. A system of fusiform or bulbous vessels radiating around the pulsatory vesicle, contract, as the vesicle expands, and *vice versâ,* as is well-known; and some seem to have several such *pulsatory* "vacuoles." The body is turgid with rather small germinal yolks. These animals I have never seen bisecting either lengthwise† or across, nor copulating sexually. The latter, however, seems to take

* The developmental experiments were made in small parcels, forming a drop (between glass-slips, somewhat held apart) and preserved from exsiccation.

† Ehrenberg's figures, however, show it in that process (if not a mistake).

place with the Planariæ, which also show the staghorn-shaped entrails analogous to those of the marine (true) Planariæ and joints of the tape-worm, whose detached individuals are also known to hover freely in a liquid, like these Ciliata. It is supposable that the large Paramecium, with pulsatory organs, is the young Planaria; but it is certainly not itself an adult body.*

The further and most remarkable of all these progressive and retrograde developments is the following. The well fed and full grown but *entrailless* Paramecium Aurelia becomes slow and lazy, grayish with the teeming germinal contents, and in a few hours may be seen motionless as the fabulous "Kraken" of ancient Norway. Its *entire substance* now commences swelling forth into compact, fragiform "germinal clouds;" while a great many of the germinal specks, now become less obscured, are plainly discernible as of the clear, "*currant-shape yolks*" kind. These in a short time however, commence *moving;* and while some of the smaller ones are being propelled by adherent motile granules (probably the "Acineta" *Auct.*), the larger ones move by contraction, viz: their "circlet" becoming *everted*, they now *crawl forth*, like a very limpid *grub*—resembling a sort of *tumbling sac!* This "tumbling" is produced by the most marvellous facility it possesses of protruding long, blunt branches, (like little stove-pipes) on *any* part of its surface, by eversion; so that in a few moments its form is entirely changed. Its contents are a visibly and rapidly circulating *so-called* "rotating protoplasm," composed of mostly very transparent *individual vibrionic particles*, partly bulky, but mostly very small. Some dark (red or brownish) vibrionic dots are also discernible.

It now takes the form which has been called "Amœba." This form, however, likewise occurs, when similar yolks or "acinetæ," are expelled from *vorticellan* bodies. In either case the "tumbling-sac" lastly attains a versatile-campanulate star-shape *with* "*pseudopodia*," from which break forth volumes of minimal vibrios, and quite large, cylindric bits of rods, or (*pseudo*)-"bacteria." The latter here are thicker than fungine bacteria, and are neither coated nor ellipsoidally shuttle-shaped, but bluntly cylindric, like cartridges or butting rams. They possess a very forcible automatous motion, and like to congregate, and with great violence keep butting all together, one against the other, in a heap; and within a few minutes, the whole appearance has dissolved and passed into a "germinal cloud" of molecular "vibrionic" cell-life.

Besides the above circuits of generations, which probably comprise both the pulsatory Paramecians proper (Aurelia)

* Pritchard, etc., figure the planaria-like form as "adult Paramecium."

and the Vorticello Oxy-trichans (through the mediation of the "oyster" or "porte-monnaie-grub"), there occur frequently some *analogous* forms, such as "Kerona" and "Trachelium."

The last form of all to appear in infusions, etc., seems to be the well-known *Rotifer*, the developments whereof are perhaps related to some of those above detailed. It is, however, most probable, according to the observations of Prof. L. Agassiz ("Ann. Nat. Hist." vol. ii, 1850, p. 157), who saw forms resembling the undulate-fleeced ("Paramecium Kolpoda") grubs *bred from the eggs of "Planariæ,"** that such are the adult forms (*if* adult). I have only occasionally met these swelled and pear-shaped, dusky bodies, traveling both back and forward with equal facility, and remarkable for the stag horn-like designs of their *entrails;* thereby evincing something like a membrane in their organization, but the organ being itself of a sort of glandular structure. They are also said to bisect, like the Oxytricha. Some *young* ostensibly planarian forms, larger than Paramecium Aurelia, blackish, and shaped like a short, broad lancet blade, which I have seen "bisecting," did so only while *encysted*, rotating in the manner of mill stones; and the escaping animals had as yet no trace of the visceral organization, as found in the adult Planariæ (and also observably developed in Rotifer).

We are therefore still in doubt as to the true, ultimate genus and species, and therefore have to *suspend* classification; the points of interest, here submitted, being the important physiological processes and transformations on the one hand, and the fallacy of foregone diagnostic terminology on the other. The description of the genetic phenomena of the so-called Fresh Water Algæ, in their *unbroken continuity of developments*, as experimentally ascertained, I reserve for a future paper.

ART. XIII.—*Tornadoes of the Southern States;* by HAMPTON S. WHITFIELD, Professor of Mathematics in the University of Alabama.

THE tornado is a storm which has two distinct movements, the one progressive along the surface of the earth, the other gyratory, like that of a top spinning on its axis. It whirls as it goes and its force is so great that no structure of wood, brick or stone can stand before it. Even the solid hills quake and the ground trembles beneath its march. Fortunately, its track in this country is very narrow. I have not yet found traces of any one exceeding two hundred yards in breadth.

* This is no doubt what authors figure and describe as the "*adult* Paramecium Aurelia," with its stag-horn shaped intestines and swelled bodies. I am also under the impression that it was *this* form which I had formerly frequently observed in what appeared to be spontaneous *coitus*.

The gyration of the tornado is not horizontal but spirally upward, for it not only displaces heavy bodies, but carries them up to a considerable elevation. I have seen a pine tree, sixteen inches in diameter and sixty feet long, float out from the black vortex of one, at the height of a quarter of a mile, and sail round, to all appearance, as light as a feather.

In May, 1868, a very destructive tornado originated in the extensive flats on the Bigbee river, south of Columbus, Miss., and crossed Pickens and Tuscaloosa counties, Ala. A few days after its passage I visited the wreck of a large, two-story, framed house which had stood in its way, twelve miles east of Columbus. The timbers were scattered for miles along its path, and all the family, five in number, were killed. Their bodies were found at some distance from the site of the house, one nearly a quarter of a mile away on the next hill. The clothing of the females was stripped from their bodies. The front portico of the house rested on a single piece of pine sixteen inches square and fifty feet long. There were no timbers framed into it and it was, therefore, moved by the force acting only on its own surface. It was carried across the intervening valley to the adjacent hill, into which it plunged end foremost, opening a deep trench. Here it shivered, and leaving a short fragment, passed on. Lying on the ground, under the portico, was a solid iron shaft, an inch and a half in diameter and weighing sixty pounds. It was transported more than a hundred yards.

To produce such results required a pressure of at least one pound to every square inch, a force fearful to contemplate as possible for the wind. Some idea can be formed of it when we reflect that this house, being fifty feet long by twenty-five in height, presented a front area of one hundred and eighty thousand square inches, and therefore encountered a pressure of ninety tons. The velocity of the wind, necessary for such an effect, must have been one hundred and sixty miles per hour. Let it be taken for granted that this velocity was at the point of greatest energy in the gyration, for it must have a point of greatest and one of least effect. The point of greatest energy or effect on stationary objects is on that side where the direction of gyration coincides with that of progression. Should the advancing speed of the storm just equal the velocity of rotation, then on one side the effect would correspond with the sum of these velocities, while on the other it would be entirely neutralized; for, on this side, the wind would move backward as fast as the tornado would go forward.

It is impossible to determine accurately the average speed of our tornadoes, but careful observation and comparison have led me to fix upon forty miles per hour as very near the truth.

This must have been about the rate of one whose formation and progress for several miles I witnessed, but the spectacle was so absorbing that I entirely forgot to time it by the watch. On another occasion, in the night, I listened, in company with several others, to the roar of one passing at the distance of two miles, and we all agreed upon forty miles as about its rate.

In May, 1840, a part of Natchez was destroyed by a tornado, the most dreadful that has ever passed through the Gulf States. It crossed the river at two o'clock, P. M., and at 9 o'clock burst upon west Alabama in the shape of a rain storm, pouring unprecedented torrents. Its rate was, therefore, about forty miles. The Pickens county tornado, if the accuracy of two witnesses, fifty miles apart, can be relied on, exceeded this rate a little. For the sake of analysis let forty miles be taken.

The progress of tornadoes is always, in the Southern States, from a point south of west to a point north of east, and, although sometimes varied by prevailing winds, this direction is characteristic and due, as I shall show, to the rotation of the earth on its axis. The gyration is always from right to left, and this, also, as is known, is an effect of the earth's rotation.

On the south side of the tornado, then, the greatest power is exhibited, for here the gyration is forward or coincident with the translation, while on the north side the gyratory motion being contrary to the progression, the effect is least. At the front and rear, where the gyration crosses the path, the effect must be the same.

Suppose, then, that the velocity of gyration is one hundred and twenty miles per hour. Add forty, the speed of progression, to the south side, and the velocity of impact, against stationary objects, would be one hundred and sixty miles per hour. Subtract forty on the north side and it would be eighty. Now, wind moving eighty miles an hour will not necessarily throw down trees and wreck buildings, but at a speed of one hundred and twenty or one hundred and sixty miles, it will level all obstructions. The most destructive energy, then, is developed in the south semi-circumference of the whirl, and the diameter of the gyration must be, in most cases, much greater than the apparent path. The aspect of the wreck along the path of these storms is in conformity with the above analysis of forces. Where they traverse forests, by far the greater number of trees are thrown eastward, and nearly parallel to the line of progression some fall northward and some southward but none lie backward parallel to the track. The framed house in Pickens county stood in the southern rim of gyration and all its fragments, together with its inmates, were carried eastward.

One of the most remarkable accompaniments of the tornado is the black column or spout, extending from the cloud down

to the surface. It precisely resembles a column of black smoke, such as pours from the pipes of a steamer burning pine wood; it is in fact condensed vapor or cloud, intensified in blackness by the dust and rubbish carried up from the ground. The tornado is a shell or hollow cylinder of air, and all its energy lies in its rotating rim which is powerfully compressed by two antagonistic forces, centrifugal and centripetal. The rapid whirl draws the air from the center toward the circumference where it is met and opposed by the in-rushing winds. There is, consequently, a rarefaction, a great reduction of temperature by expansion, and condensation of vapor within the shell.

The spout does not hug the earth continuously, but rebounds or *ricochets* along the uneven surface, often skipping the valleys but generally desolating the hills. It is disposed, however, at every recurrence to strike at the same points. It is not an established fact, but it is commonly believed, and with some reason, that the tornado does, in the course of years, return along its beaten path, and that it is unsafe to build where one has ever passed. The house in Pickens county stood on a hill from which a log cabin had been blown away some thirty years before. I witnessed the last of three, which have passed along the same track. Near Hernando, Miss., three have followed an unvarying line. It is probable that there are some localities more favorable than others to the generation of these storms, and if this is true, then the law of direction, hereafter explained, accounts for their progress along the indicated path.

Such an opportunity, as fell to my lot, of witnessing the formation and course of a tornado is rarely enjoyed, and the phenomena observed on that occasion are of great value in illustrating the origin of these whirlwinds. On the 29th of April, 1867, at 10 o'clock A. M., I was approaching Tuscaloosa, on the Elyton road, the general direction being east and west. The weather was hot and oppressive, while a perfect calm prevailed both at the surface and in the upper regions, for the leaves were not stirred upon the trees and the heavens were covered with fragmentary clouds, perfectly at rest. Occasional large drops of rain fell, and there was, now and then, lightning. The atmosphere was evidently surcharged with vapor and in a condition of great electrical excitement. At the distance of three and a half miles from town, an elevated ridge, over which the road passed, afforded an extended view, and I saw a mass of black cloud, detached and hanging over the western horizon. It appeared nearly circular in shape with the exception of a slight angular projection, like an inverted cone, at its lower edge. I afterwards ascertained that it was at this time about five miles distant from me, and a calculation, based upon the estimated angles, fixed the elevation of its base above the sur-

face at about fifteen hundred yards, and its diameter, considering it a sphere, at about six hundred. It was entirely at rest.

The first view of this cloud suggested to me the possibility of a tornado, and I watched it closely as I drove along in my buggy. While I was driving, leisurely, more than a quarter of a mile, it maintained its position and outline unchanged. At length a farm house with its shade trees intercepted the view for about a minute, and when I came again in sight of it, the projection beneath the cloud appeared in violent commotion. There was now no longer any doubt of the character of the phenomenon about to be exhibited, and satisfied, from a knowledge of the general direction of tornadoes, that it must come near me, I leaped from the buggy and released the horse as quickly as possible, in order to give him a chance for his life. This did not occupy more than a half a minute, and when I turned to look again, the black column was formed, reaching from the cloud to the ground. A few moments showed that it was rapidly approaching. I remember noticing small fragments of cloud moving toward it from the north, but there was no perceptible breeze where I stood. When about a mile distant I saw that it would go south of me, and at this time I first observed the surface drift, which appeared like an innumerable flock of birds, flying around the summit of the column, and here, too, the pine tree spoken of emerged from the vortex, and settled slowly to the earth. The column was now much shorter than when first formed; the cloud had descended much nearer the surface. It passed about three hundred yards south of my position and at this point the first electric discharge took place. The lightning zigzagged down the column, shedding through it a lurid glare. The roar was deep-toned and powerful. The gyratory motion was distinctly visible. When a little further on, it became so enveloped in clouds as to be no longer distinguishable, but I knew, by the now frequent peals of thunder, that it was increasing in violence and levelling all things in its path.

This tornado was formed about a mile and a half southwest of Tuscaloosa, over an extensive marshy flat, where an observer characterized it as a "big whirlwind." It was not destructive at first but grew in energy as it progressed, and two miles from its starting point, threw down a dilapidated building. About six miles from Tuscaloosa it struck a log cabin in which were sitting a woman and several children. Every log above the floor was carried away, while the occupants were left uninjured. Twelve miles further on it performed a similar feat, taking off every log of a house without the slightest hurt to any of the family, all of them having taken refuge within on its approach. This is remarkable, but there are other like instances well au-

thenticated, and it is commonly believed that a log house is the safest retreat. The direction of this tornado was east by 20 degrees north. After its passage the air was cool and pleasant, and, at 4 o'clock in the afternoon, heavy rain came from the north, followed, for the next few days, by clear weather with northwest winds.

The most remarkable fact, disclosed by the phenomena of this storm, is the inherent power of progression which it unquestionably possessed. After the gyration was established it began at once to travel eastward, not driven by any wind, but ploughing its own way through the tranquil atmosphere with tremendous speed. Here is presented a problem, which, so far as I know, has not heretofore been propounded. Its solution is important to the science of meteorology. The fact that tornadoes invariably move from the southwest to the northeast is well established, as also the fact that, by an impulse acquired from the earth's rotation on its axis, they gyrate from north by west to south. This backward gyration is thus explained: All parallels of latitude decrease in diameter, and therefore in circumference, as we go toward the poles of the earth. As they all revolve in twenty-four hours, it follows that every one, approaching the pole on either side of the equator, moves around more slowly than the one preceding it. Therefore, a current moving southward, to the vortex of a tornado in the northern hemisphere, finds that vortex rotating eastward with a superior velocity, and is left behind, or, projected to the west, while, for the same reason, a current blowing northward to the vortex, finds it rotating with inferior velocity, and, preserving its own easterly momentum, is hurled forward or projected to the east. Thus the south half of the rim being impelled eastward, and the north half westward, the backward or left-handed gyration is fixed and maintained. Just the reverse is true in the southern hemisphere of the earth, while on the equator the gyration would be free to take either direction.

Espy denied the whirl of tornadoes, while Redfield, another eminent writer on the subject, maintained it. The question has, I believe, long been settled in favor of the latter.

I now propose to show, also, that the translation of tornadoes from west to east is effected by the earth's rotation on its axis. But, as this proposition is in conflict with the theory of cause and formation, as enunciated by Espy, and supported by the higher authority of Loomis, it will be better to state briefly that theory.

"Storms," says Loomis, including tornadoes, "are caused by a strong and extensive upward motion of the air, by which means its vapor is condensed by the cold of elevation." To epitomize his language, the rays of the sun heat the surface of

the earth without heating, except slightly, the atmosphere through which they pass. The surface warms the air near it, while, at the same time, radiation more easily takes place from the superior strata, thus reducing the temperature of the upper regions. Since air expands and grows lighter with increase of temperature, and contracts and becomes heavier from diminished heat, it follows that, under this influence, "the atmosphere is in a state of unstable equilibrium, *and the lower strata tend continually to rise and take the place of the upper.*" The ascending air, coming under diminished pressure, expands, and therefore cools. At a variable height, depending on the dew point, or the quantity of vapor, the cooling causes condensation or cloud. Condensation of vapor sets free latent heat. This liberated heat warms the surrounding air and causes it to ascend higher. Another expansion takes place, followed by another cooling, another condensation, and another liberation of latent heat, and so on indefinitely, or until all the vapor held in suspension is disposed of. Thus dense clouds of great depth are formed, and rain, hail or snow, two, or all, result. The ascending column is continually fed by surface currents converging to the center, and the violence of the storm is in proportion, as Espy says, to the "steam power" of the air; that is, the amount of vapor suspended in it.

Olmsted, in a lecture on Espy's theory, has, I think, shown that this process of alternate cooling and heating is impossible. The truth is, that the liberation of latent heat simply serves to retard the too rapid condensation, and without this check the violence of storms thus produced would be tenfold greater.

There can be no question that rain is caused in this way. The piled-up clouds, called *cumuli*, so common in summer, are produced by ascending currents, and from them result ordinary summer showers, but there is a vast difference between the summer shower and the tornado; so great, in fact, that we are compelled to attribute them to entirely different modes of generation.

In quoting Loomis, I have italicized one sentence. Owing to the "unstable equilibrium," caused by surface heat and radiation above, he says: "*The lower strata tend continually to rise and take the place of the upper.*" Here he has stated the effect for the cause. The fact is, that *the upper strata tend continually to descend and take the place of the lower.*

Espy, endeavoring to establish a favorite theory, makes the quite untenable assertion "that the air of the upper regions is specifically hotter than the air at the surface;" which means, if it means anything, that a pound of air in the upper regions contains absolutely more heat at a given temperature, than a pound at the surface. All this belongs to a philosophy which has been long since exploded; and in fact, every sound philoso-

pher must at once perceive that, under such conditions, no currents could either ascend or descend; the "specifically" hotter, and therefore lighter air, at the top, could not possibly come down, because it would become *sensibly* hotter, and therefore lighter than the air below; and the "specifically" colder air at the surface could never rise, for a corresponding reason. An "unstable equilibrium" could not exist. My prescribed limits forbid a more elaborate discussion of this point.

If an "unstable equilibrium" exist, the upper strata will tend to sink, and *a descending current must necessarily produce an ascending current.* Again, the "unstable equilibrium" requires that the air from the upper regions, when it reaches the surface, should, notwithstanding its compression, be colder than the surface air, or else it could not undermine and force it up.

This descending current may be a contracted column, pouring down rapidly, or it may be the entire body of the atmosphere settling slowly over a wide area. The latter process goes on where there is any local cause of heat, as in the case of fires, and the expanded column is pushed up by the surrounding air pressing upon its base. The former takes place, under favorable circumstances, when a great expanse of air is heated up uniformly at the surface. Here the descending stream is a rapid spouting column, and the ascending one a slow compulsory uprising of the whole body of surrounding air. In this case, if the temperature of the falling air is below the dew point of the lower strata, condensation takes place and cloud is formed. If the difference is very great the down-moving current will be very powerful, and the centrifugal force resulting from its gyration will generate an immense vacuum or vortex, into which the air from beneath will rush violently, forming a secondary vortex, which is the spout of the tornado. Should the ascending current fail to concentrate into a spout, the storm is known simply as a hail-storm. These differently named movements have a similar origin, and present similar phenomena. Nearly every tornado exhibits hail, and nearly every hail-storm, at times, a spout. At a considerable elevation the descending column, before it is compressed to any great extent, is icy cold, and, by expansion in the vortex, its temperature is reduced ten fold, so that the vapor of the air rushing in from below is instantaneously frozen.

The tornado is, then, a tremendous maelstrom in the atmosphere. Its vortex, extending possibly to the utmost limits of the air, and widening out at the top, involves a vast extent of the upper strata in its commotion, often giving raise to rain storms and secondary tornadoes many leagues distant from its path. Its prodigious force is due to the concentrated momentum of all the currents moving to the common center; is the

sum of the forces of all the centripetal streams set free in a contracted area.

It is a well-established fact that tornadoes are translated from west to east. It is also admitted that they are generated in a calm atmosphere. It is, therefore, surprising that Espy and other advocates of the "ascending column" theory, did not perceive that their storms must, unavoidably, be translated in the opposite direction, or from east to west. As the earth rotates to the east, carrying the atmosphere along, it follows that the greater the elevation or distance from the axis, the greater must be the velocity eastward. Hence, an ascending column, penetrating the upper and more rapid strata, is left behind or projected to the west. Overlooking this principle, however, they assign as the cause of the direction of tornadoes an elevated and constant eastward wind, maintaining that it seizes the top of the tornado and drags it as a ship drags its anchor. But there is no cohesion in æriform columns, as in cables, and it is, therefore, impossible for a force applied at the summit to pull the base along. Espy contradicts his own theory frequently by asserting that the tops of rising columns, forming cumuli, are "shaved off" by upper currents. It is very evident that if a strong wind from the southwest should be blowing at a great elevation while a tornado, formed according to Espy's theory, is raging in an underlying calm, the earth's rotation would carry the storm westward, notwithstanding the contrary wind above, for this would simply "shave the top" and bear it off, while the storm went on the opposite course.

There is but one way in which an elevated current can affect the direction of a tornado, and that is *by descending into its vortex.* In this mannner only can it communicate its own momentum and control the path, and in this manner it often does produce a great variation from the normal line. Neighboring winds, bordering the calm in which the storm originates, may also, in a way easily explained, cause a deflection.

It has been shown that a column of air ascending in a calm must be deflected to the west by the earth's rotation. For the same reason one descending must be impelled eastward. Tornadoes always travel from west to east in obedience to this law.

The process of formation is now easily comprehended. In an atmosphere supersaturated and unduly heated at the surface, let a calm prevail over many miles of territory. The equilibrium is powerfully disturbed. A great volume of elevated air begins to settle down, forcing up the lower strata. In descending it meets and mingles with the warm, moist air beneath, forming cloud. Whatever latent heat may be evolved by condensation is at once reabsorbed by accessions of cold air from

above. The descending stream, fed by oblique tributaries from all points of the compass, begins to gyrate. From centrifugal force result rarefaction, cooling, and further condensation. The center of the vortex is a partial vacuum, and from below a column is drawn up into it. This ascending column also takes on gyration, and the tornado spout is created. But this spout, the effect of which is so terrific, is nevertheless secondary and incomparable to the tremendous commotion of the great whirl above. The two columns meeting, vast volumes of air are thrown off by centrifugal force in all directions, and the cloud expands and enlarges with amazing rapidity. This expansion is often mistaken for the progression of the storm; the cloud appearing to approach one observer from the northwest, perhaps, while another sees it rolling up from the south. In the meantime the descending stream has pressed the cloud down upon the surface, where it envelopes everything along its path in almost total darkness. At length the superior vortex becomes so great in diameter that the spout is disrupted or so diffused as no longer to exhibit the concentrated power of the tornado. The whirl becomes co-extensive with the overhanging cloud, and the meteor is now a rain or hail storm of tremendous violence. The tornado of April, 1867, near Tuscaloosa, raged as such for about thirty miles, when it lost its distinctive feature, the spout, and poured such torrents as to cause a great freshet in the Warrior river. It has already been stated that the Natchez tornado expended itself in a tremendous rainfall, and this is the termination of all these storms. They are of variable duration and extent, continuing until the equilibrium of the atmosphere is restored.

Loomis has explained, but not to entire satisfaction, the cause of the northward inclination of tornadoes. He rightly ascribes it, however, to the decreasing diameters of the successive parallels of latitude. If a tornado should form on a parallel of 45 degrees, its vertical axis would make an angle of 45 degrees with the earth's axis of rotation. It follows, then, as would readily appear from a diagram, that the currents descending obliquely to the vortex on the south side, would approach the earth in a direction more nearly perpendicular to its axis than would those descending on the north side, for the latter would be more nearly parallel to the earth's axis. Then, by reason of the earth's rotation, the eastward impulse of these southern currents would be greater than the westward impulse of the northern currents. The deflection of the former would be greater than that of the latter, and, consequently, velocities corresponding, there would result a greater centrifugal tendency on the northeast than on the southwest of the vortex; and the effect increases with the latitude.

This will plainly appear from a diagram. Let a circle be described representing the rim of a tornado. Then let two lines be drawn, one representing the resultant of the forces of the southern currents, and the other the resultant of the forces of the northern currents, each deflected as it approaches the vortex, but the former more than the latter. Each will maintain its influence, from its point of contact, around to the point where the other impinges, and that from the south, having the greater impulse, and, acting on the northeast semi-circumference of the rim, will press the storm northward.

The process of hail-formation takes place in the great vortex above the base of the cloud, probably at considerable elevation. There the gyration, not impeded as it is at the surface, presents a vast and rapid whirl, the centrifugal force of which causes extreme rarefaction, accompanied with intense cold at the center. The saturated air carried up into it from below, by the spout, furnishes the material for hail. Congelation follows instantly upon condensation, and the stones, tossed about in every direction, are finally thrown out upon the circumference, where they are free to fall.

Electricity, which has been supposed to play an important part in the generation of tornadoes and hail storms, is but an effect. It is excited and set free by the condensation of vapor, and is developed in proportion to the amount and rapidity of cloud-formation. In the Tuscaloosa tornado the gyration had formed and travelled three-and-a-half miles when the first flash occurred.

The tornado may be looked for in the winter and spring months, during the prevalence of southern winds. As stated above, a descending column requires, as a prerequisite, a surface stratum uniformly heated over a wide extent. As the sun advances north, after the winter solstice, the south winds that reach us blow from low latitudes on the Gulf. They have then, not only abundant moisture, but a temperature higher than is due, at any time before June, to the effect of the solar rays in our own latitude, and therefore answer the necessary condition of a stratum heated uniformly over a large area. Our tornadoes consequently do not grow out of the heat rays that penetrate our latitude, but rather from the heat of the tropics, transported hither in the winds; and this is the reason of their appearance either in the daytime or night. We never witness them in the hot summer, because then the lower atmosphere is warmed by direct rays, and a uniform temperature, over a wide extent, is impossible, from the fact that the cleared lands and forests, hills and valleys, are heated unequally, giving rise to ascending columns and moderate storms. If the theory of Espy were true, then July, August, and September

would be the tornado season with us, for in these months moist south winds blow, and the sun's rays are most powerful.

The cause of the greater violence of storms produced by descending air is not difficult to comprehend. When a downward column becomes well defined, it is fed, as before suggested, by tributaries flowing obliquely down from all sides. The very top of the atmosphere sinks freely into the stream. The case is precisely that of a heavy body descending an inclined plane; but the heavy body is here a great ocean of air superimposed upon another abnormally elevated in temperature, and therefore abnormally rarefied. The tornado is a process by which the one seeks to settle beneath the other, and is not unlike what would occur should an opening be made through the bottom of some great reservoir of water.

On the other hand, when the transposition begins in consequence of the movement of a definite column, ascending from below, the earth's surface presents a limit, and the tributaries cannot, as in the other case, flow obliquely in straight lines without leaving a vacuum beneath, and that is impossible. They must, therefore, though ever seeking to mount upward, still trail along the surface until they converge at the center. An impediment of this nature would find adjustment in many uprising columns of limited power, capped with cumuli and resulting in showers, but no one vast, absorbing vortex, could monopolize the whole movement, and shake the firmament with its might.

The effects of the tornado are often, to all appearance, very anomalous and extraordinary. It strips the feathers entirely from fowls when the gust strikes them from behind. In a row of buildings in a line with its direction, it may throw down the middle one, and leave the others standing. This is possible when they are located on the central line of progression, for then the blow is delivered by the front and rear of the rim, gyrating at a right angle with the row, and every house must stand or fall, according to its own power of resistance. Or, if a firmly-built house withstand the outward shock, it may yield to the elastic force of its inclosed air, expanding, as it must, with a sudden and powerful effect, that instant the vortex, which is a partial vacuum, passes over it.

Again, pointed pieces of wood or iron pierce or penetrate wherever they strike end-foremost, and pebbles are imbedded in soft wood by the force of the blast. This is not so remarkable when we reflect that the velocity of gyration is three hundred feet a second—and it may go far beyond that—which is greater than the speed of an arrow shot from a bow. On the track of the Pickens county tornado a rafter of a house was found driven through a pine tree.

The whirling sand storms of the desert are probably tornadoes without the accompaniment of clouds with thunder and lightning. The great desert of Africa presents an uninterrupted surface of sand to the sun's rays. The lower strata over its broad expanse are heated uniformly, and this first requisite is answered. But the dryness of the air fixes the dew point at an extremely low degree, and there can consequently be no condensation or cloud. Yet the vortices may form as in other localities, and vast quantities of sand take the place of cloud.

My information is too limited, however, to justify any positive theory in regard to these desert storms. I merely conjecture that they are formed like the tornadoes of our States, but that, unlike them, they are generated from direct heat rays absorbed by the surfaces immediately under them, and therefore appear generally in the daytime, and in the summer months, as well as at any other period.

Art. XIV.—*Preliminary Notice of New North American Phyllopoda;* by A. S. Packard, Jr., M.D.

The following brief descriptions are extracted from a monographical notice of our Phyllopod Crustacea, which, with the exception of the Branchipodidæ, so thoroughly investigated by Prof. Verrill, have been sadly neglected. It will be noticed that North America is rich in the species of Apus, more so than any other quarter of the globe so far as yet known. It is a little singular that no species has yet occurred east of the Mississippi river. The species of Limnadiadæ are probably more abundant than naturalists are aware of, and the attention of collectors of shells is called to these Cyclas-like shelled Crustacea, whose shells may not infrequently be mistaken and passed by as simply species of Cyclas. For the privilege of studying the species of Apus I am indebted to Dr. William Stimpson, who has loaned me the specimens placed on deposit in the Chicago Academy of Sciences by the Smithsonian Institution, and to Prof. A. E. Verrill, who has contributed the specimens in the Yale Museum; while the Museum of Comparative Zoology at Cambridge has contributed a new Apus from northern India, and for the Limnadiads my acknowledgments are due to Mr. G. W. Belfrage, an industrious collector, and Prof. E. S. Morse, who have given several species to the Peabody Academy of Science.

Apodidæ.

The known species of Apus may be for convenience divided into three sections, characterized in part by the length of the

shield, or carapace, the highest forms having the shortest carapace, those with the longest shields, as the European *Apus cancriformis*, approximating in this and other characters to the genus Lepidurus.

Section *a* comprises *Apus longicaudatus*, *Lucasanus*, *Newberryi*, and probably *Domingensis*.

Section *b* comprises *Apus æqualis*, and *Guildingii*.

Section *c* comprises *A. cancriformis* and *Himalayanus*.

Apus longicaudatus Leconte, Ann. N. Y. Lyceum.

Prof. Dana's type specimen, which is now very imperfect, was labelled "Rocky Mountains, near Long's Peak." Four specimens from "Texas, J. H. Clark, No. 3." Three specimens from "pools near Yellowstone river. Dr. Hayden, No. 6." Mus. Chicago Acad. Both sexes occurred, the females having eggs. James's *A. obtusatus* (Long's Expedition) is probably this species. *A. Numidicus* Lucas, from Algeria, in the form of the carapace seems to be allied to *A. longicaudatus*.

Apus Lucasanus, n. sp.—♂ closely allied to *A. longicaudatus*. The frontal doublure rather longer than in *longicaudatus*, and hypostoma a little smaller. Maxillipeds shorter and smaller, and telson longer than in the preceding species, with three median spines above. Anal stylets less spiny.

No. of segments behind posterior edge of shield 33; no. behind the last pair of gills (including telson) 13; length of body (excluding caudal stylets) ·94; of carapace along the middle ·37; total length of carapace ·48; length of tergal carina ·24; distance from anterior end of carina to front edge of carapace ·16; length of caudal stylets ·57; being a little over half the length of body; breadth of shield ·40 inch.

Six specimens in a bottle labelled "Kansas, No. 5," and containing thirteen ♀ *A. æqualis*. Mus. Chicago Acad. They cannot be distinguished from St. Lucas specimens.

♀, carapace longer than in ♂, and caudal stylets not so heavily spined. No. of segments behind posterior edge of shield 29; no. behind last pair of feet 11; length of body ·80; of carapace along the middle ·30; total length of carapace, ·40; length of tergal carina ·25; distance from front end of carina to front edge of carapace ·16 (stylet broken); diameter of egg-sacs ·09 inch.

One specimen from "Cape St. Lucas, John Xanthus, No. 4." Mus. Chicago Acad.

Apus Newberryi, n. sp. ♀.—This fine species differs chiefly from *A. longicaudatus* in the shorter maxillipeds, and much longer, smooth telson with 3 instead of 4 median spines, and in the smooth, finely spinulated caudal stylets, while the carapace is longer. No. of segments behind posterior edge of carapace 29; no. beyond last pair of feet 11; length of body 1·78; of

carapace along the middle ·75; total length, 1·00; length of tergal carina, ·50; distance from front end to front edge of carapace ·30; length of caudal stylets, 1·05 inch.

Two specimens from "Utah, J. S. Newberry, No. 1." Mus. Chicago Acad.

A. æqualis, n. sp. ♂.—In this species the carapace is much longer than in the preceding species, the eyes are larger, the tubercle behind them is smaller, and the gills reach much nearer the telson.

No. of segments behind posterior edge of shield 23; no. behind last pair of feet 11; length of body 1·15; of carapace along the middle ·56; breadth ·56; length of tergal carina ·35; distance from front end of carina to front edge of carapace ·21; length of caudal stylets ·75 inch.

Two specimens from "Matamoras, Mexico, General Couch." Mus. Chicago Acad.

♀. The telson has 5 median spines and is shorter, and the stylets have more numerous and shorter spines than in *A. Newberryi*. The under side of the telson is much smoother than in *A. longicaudatus*, and the outer gill of the 1st maxillipeds is a little longer and more acute. No. of segments beyond the hind edge of carapace 25; no. beyond the last pair of feet 9; length of body 1·07; length of carapace in middle ·56; breadth ·46; length of carina ·33; length from front end of carina to front edge of carapace ·23; length of caudal stylets ·75; diameter of egg-sac ·24 inch.

Thirteen specimens from "Matamoras, General Couch" and "Kansas No. 5," Mus. Chicago Acad., and a specimen from Yale Museum labelled "Plains of Rocky Mts., no. 390."

Apus Guildingii Thompson, Zool. Researches, Jan. 1834, p. 108, belongs to the same section of the genus as *A. æqualis*, but the 4th branch of the 1st maxillipeds is longer than in any other species known to me, being represented as reaching almost to the end of the caudal stylets. St. Vincent, West Indies.

To the third section of the genus belongs the European species *A. cancriformis*, and the following species from North India. They differ from the North American species in the longer carapace, the smaller eyes, and round postorbital tubercle, the less spiny telson, the more hairy caudal stylets, and the larger hypostoma.

A. Himalayanus, n. sp. ♀.—Frontal doublure and hypostoma as in *A. cancriformis;* the first pair of maxillipeds are of about the same length as in *cancriformis*, but the joints are more numerous and smaller, there being 80 joints in the longest branch, while in a specimen of *cancriformis* four times larger, there are 50. The telson is longer than in *cancriformis*, but the number and arrangement of the spines is the same, as is the

under side. The stylets are scarcely as long as the body, while in *cancriformis* they are considerably longer, and the fine spines are a little stouter. No. of segments beyond the hind edge of carapace 19 (in *cancriformis* 19); no. behind last pair of feet 7 (in *cancriformis* 6); length of body 1·00; length of carapace along the middle ·64; length of carina, ·45; distance from end of carina to front edge of carapace ·36; length of caudal stylets ·95; diameter of ovisac ·15 inch, ovisacs situated on the 11th pair of maxillipeds as in all the other species of the genus known to me.

"Collected from a stagnant pool in a jungle four days after a shower of rain had fallen. For five months previous to this rain there had been no rain upon the earth. Himalaya Mountains, North India, near where the Sutlege river debouches into the plains. April, 1870." Mus. Comp. Zoology, Cambridge. Two specimens.

Branchipodidæ.

Streptocephalus Texanus, n. sp.—The male differs from *S. similis* Baird, from St. Domingo, to which it is otherwise closely allied, in the longer branch of the inferior antennæ being much longer and slenderer at tip (according to Baird's figure), while the shorter branch is much narrower. In the female the ovisac reaches to the penultimate segment of the abdomen, while according to Baird's figure it scarcely reaches to the end of the 4th segment from the end, and the second antennæ are represented as being much larger than in our species. The male organs arise from the 8th segment from the telson, and the 15th of the body; and are simple, unarmed, slender, cylindrical, very long, and curled around (in alcoholic specimens) so as to touch at their insertion. Total length, male, ·65; length of longer appendage of 2d antennæ ·17 inch; caudal stylets ·13; length of male organs when extended ·13. Female ·55 long, caudal stylet ·11; ovisac ·20 inch. "Waco, Texas. Found in the summer in the same pool as the Limnadia was taken. The pool was formed by the summer rain, and as it had passed a considerable time in a dry condition, I suppose this species appears much later, or at least not at the same time as the Limnadia." G. W. Belfrage. It also occurred in April, the females having eggs, as did those found in the summer of the year previous.

Limnadiadæ.

Limnadia Texana, n. sp.—Eyes double, but with the inner edges contiguous; pyriform tubercle behind them one half as large as the eye-bearing prominence; ·20 segments behind the fore-head, including the telson; 15 pairs of feet. Antennæ with 8 joints on each branch, the 7th and 8th joints subdivided each into two subjoints; the setæ slightly plumose on the basal

joints. Telson with 16 fine teeth, not including the terminal acute spine. Caudal lamellæ long and slender, cultriform; under edge slightly curved, fringed with long hairs, those at the base slightly plumose; the upper edge straight; end blunt. Carapace valves rounded oval, pure white; 5 lines of growth; shells minutely dotted, the markings being coarser at the posterior end of the shell, and about the region of the adductor muscle. Length of shell ·27; breadth ·16 inch. It is much longer and narrower than *L. Americana* Morse, and with a less number of lines of growth, the latter having 18; in this respect it is much nearer *L. Hermanni* of Europe, though the shell is much narrower. Compared with Baird's figure of *L. antillarum* from San Domingo, to which our species is nearest allied, the shell is more rounded ovate at each end, being somewhat truncated. While the ends of the caudal stylets are said in *L. antillarum* to be "somewhat curved, sharp pointed and slightly serrated on upper edge," the tip in our species is blunt, smooth on the upper edge, and ends in a slight hook. *L. antillarum* is also said to have joints to the rami of the 2d antennæ, and 18 pairs of feet.

One specimen, Waco, Texas. "Quite common in many places in western Texas in the early spring. It occurs in muddy pools made after rains, and totally disappears with the first drying of the pools. As far as I have seen they are only found in the woody bottom lands and always near creeks. It occurred in the same pool as Streptocephalus." G. W. Belfrage.

Estheria Belfragei, n. sp.—Rami of the anterior antennæ with 16 joints, 17 pairs of dorsal spines exclusive of those on the telson, which are 15 in number (in *E. Mexicana* they are much more numerous) and the middle one is much larger than those near it. The spines on the telson are fewer in number and larger than Claus represents in *E. Mexicana;* caudal stylets longer and slenderer than in *E. Mexicana*, and the terminal spine is longer and slenderer, judging from Claus' figure.

Carapace valves with the umbones situated at the anterior third of the shell; dorsal edge straight behind the umbones, slightly serrate, bent rather suddenly downward at two-thirds of the distance from the umbones to the posterior end, the end being full and rounded; anterior dorsal edge slopes rapidly from the umbones, and the anterior end is full and convex. Umbones prominent and rather acute, but not oblique. About 24 lines of growth, between which the shell is coarsely punctate; from 5–8 dots (when placed in a straight line) between the lines in the central part of the shell; these punctures are reduced to a single row on the edge. Length ·30; breadth ·23; thickness ·15 inch.

It differs from *E. Mexicana* Claus (Grube's figure) from Zimapan, Mexico, in the umbones being much more prominent; in

the prominent angle of the dorsal posterior edge, while there are half as many lines of growth. From *E. Dunkeri* Baird, also from Zimapan, it differs in the less numerous lines of growth; in the smaller, less tumid umbones, and the more marked angle of the posterior part of the dorsal edge. The punctures between the lines of growth are much more numerous in *Dunkeri*. Six specimens. Waco, Texas, April, G. W. Belfrage.

Estheria Morsei, n. sp.—Shell intermediate in form between *E. Caldwelli* Baird, from Lake Winnepeg and *E. Dunkeri* Baird, from Zimapan, Mexico; shell much swollen, oblong oval, of a pale horn color; umbones large, prominent, larger than in *E. Caldwelli*, and much less oblique and situated nearer the anterior end of the shell. Dorsal margin shorter than in *E. Caldwelli*, and in front of the umbones, instead of being straight and suddenly curved downward, is regularly rounded as in *E. Dunkeri*. Behind the umbones the shell is narrower than either in *Caldwelli* or *Dunkeri;* the dorsal edge sloping rapidly downward, without the well marked angle of *Caldwelli*, or the continuous, full curve of *Dunkeri*. Coarse punctures between the ribs, rather coarser than in *Caldwelli*, there being on an average 5–10 between the ribs in the center of the valve. Length ·50; breadth ·33; thickness ·24 inch. Six specimens from Dubuque, Iowa, collected by Rev. A. B. Kendig. Dedicated to Prof. E. S. Morse, who has indicated to me that the species was undescribed.

Lymnetis gracilicornis, n. sp.—This interesting form may at once be known from *L. Gouldii* Baird, recently found by Mr. E. Burgess in Cambridge, Mass., by the long slender 2d antennæ which have about 20 joints, and are much longer than in that species. The keel on the front of the head does not reach to the front edge, while in *Gouldii* it does. Shell of the same form but much larger than in *Gouldii*. Length of shell ·17, breadth ·16 inch.

Peabody Academy of Science, Salem, Mass., May 20, 1871.

Art. XV.—*On a New Difference Engine;* by Geo. B. Grant.

The great labor and expense involved in the construction of reliable astronomical and nautical tables by mental computation, as well as the impossibility of getting them entirely correct, suggested to Charles Babbage the idea that this work might be done almost entirely by machinery, and the machine he invented for that purpose has become famous, as one of the most complicated and costly pieces of mechanism ever contrived. The English government appropriated eighty-five

thousand dollars for its construction, on the strong recommendation of a committee of the Royal Society, containing some of the most eminent men of the time, but after years of study and labor had been spent on it, the appropriations were stopped on account of the indefinite expense. Though never completed as a working machine, it proved the feasibility of the scheme.

Babbage's idea was carried out more successfully by Edward Scheutz, and the two machines constructed on his plan are the only ones ever built for this purpose. One of these was bought for the Dudley Observatory at Albany, but has been but little used. The other was built by the British government in 1862, and has since been extensively used in the calculation of life insurance tables.*

The idea of contriving a machine for calculating tables first occurred to myself while laboriously computing a table for excavation and embankment. Having never heard of either Babbage's or Scheutz's engines, I imagined it an easy matter, but gave it up in disgust after some study. Last year I heard of Babbage's engine, became interested again, and designed a machine that might possibly have worked, but I could convince nobody that it would do so, and gave it up again. About four months ago, my teacher in the Mining School, Prof. Wolcott Gibbs, asked after the design, encouraged me in my work, and the result is the design for the difference engine, which it is the purpose of this article to describe.

Though I have built no large machine, the efficiency of the design for its purpose may be considered as having been proved, as through the liberality of the superintendent of the Coast Survey, Prof. Benjamin Peirce, I have been able to build a model of small capacity, which has worked to satisfaction.

I am indebted to Mr. John N. Bachelder of Cambridge, as well as to Professors Eustis, Winlock and Whitney, of Harvard College, for encouragement and help given. Mr. Bachelder had charge of the Scheutz engine when it first came to this country, and is one of the few who have had practical experience with any machine of this class.

A short explanation of the method of differences may not be wasted on many of my readers.

If the first term of any table be subtracted from the second, the second from the third, and so on, a new table will be formed, called the first order of differences. In the same way

* Accounts of Babbage's engine may be found in the Edinburg Review, July, 1834, in Taylor's Scientific Memoirs, v. 3, and in the inventor's work, "Passages from the Life of a Philosopher;" short articles on the same in Tomlinson's Cyc. of the Arts and Sciences; Harper's Mag., 1865; Manufacturer and Builder, 1870; Timb's Stories of Inventors, &c. Scheutz's engine is described in "The Swedish Calculating Machine," by Charles Babbage, in "The Manufacturer and Builder," Aug., 1870, and in detail in the British patent specifications, Oct. 17, 1854, No. 2216.

a second order can be formed from the first, a third from the second, and ultimately an order of differences will be reached, which is constant or nearly so. For example, take a table of the cubes of the natural numbers, and forming the several orders of difference, it is found that the third order is invariably six.

Table.	1st order.	2nd order.	3rd order.
1	7	12	6
8	19	18	6
27	37	24	
64	61		
125			

It is plain that with nothing but the first terms 1, 7, 12 and 6, the table might be constructed to any extent by simple addition. A difference engine is nothing but a machine to operate this method, using several orders of differences, and a large number of decimal places.

In logarithmic, trigonometrical, and in fact in the greater number of tables, there is no constant order, but one can be found that is so nearly so, that the error of considering it exactly so will not creep into a given number of decimal places, till any required number of terms have been calculated. A fresh start must then be taken, and the table completed by a number of such operations.

This engine, like both the others, consists of a calculating and a printing part. In the printing part, the calculated results are stamped into a sheet of lead, wax or other plastic substance, from which a stereotype plate is taken for printing the table, thus avoiding constant error in copying the numbers and setting them up in type from manuscript. No description of this part is given, as it contains nothing new of importance.

The calculating part consists of the main wheels, A, on which the first terms are set up, the additions made, and from which the calculated results are taken by the printing part; the drivers B, which make the additions, and the carrying apparatus C.

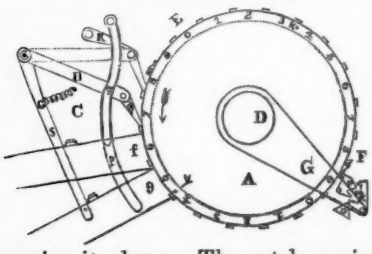
The main wheels are about one-third of an inch thick, and five inches in diameter, all turning on the same axis D, in the same direction independently of each other, the axis being stationary.

They are arranged in sets of two, three or more, according as the first, second or higher order is designed to be constant. There are as many of these sets as there are decimal places in the largest number to be used. Each wheel is furnished on one edge with twenty teeth, and on the other with two cams, a and a', which project a little farther from the wheel than the teeth. The spaces between the teeth are stamped with the ten numerals, zero to nine, twice in succession.

The first set represents the units or lowest decimal place, the next set represents the next higher decimal place, and so on. The first wheel in each set represents the corresponding decimal place of the tabular number, the second wheel, that of the first order, and the last wheel is the constant order, and is furnished only with a cam, the teeth being omitted. It can be fastened at any figure, as it never requires to be changed after once being set. By this arrangement each wheel is separated by but the sixteenth of an inch from the wheels of the same place in the next higher and next lower orders.

The point E is chosen as the point at which to read all numbers, and it is evident that any number may be shown on any order by turning the wheels till the right numbers appear at E. The cams are so arranged with regard to the numbers, that one of them shall be at the point F when the wheel reads zero. Now as the wheel is turned, as every number passes E, the cam will be moved one space further from F, so that at any time the wheel could be read as well by observing the number of spaces the cam is distant from F, as by reading the figure at E.

The drivers B are attached to the carriage G, one driver opposite each wheel except the constant ones. They consist of a catch *b* and hook *c*. The catch is pressed toward the wheel, and the hook pressed on the catch by the same spring *d*. The carriage is driven by a crank over ten spaces on the wheels, and back again, making one oscillation to every turn of the crank. As the carriage leaves the rod *e*, the catch drops between the teeth of the wheel and carries it along. The catch projects over its wheel far enough to strike the cam on the next wheel when it gets to it, and be lifted out of the teeth by it, having added to its wheel the number of spaces that the cam is distant from F. As it is raised up, the hook catches in the nick *h*, and prevents it falling back on the wheel, so that it moves the rest of the stroke and back without moving the wheel. As the carriage comes back, the projection on the hook strikes the rod *e* and the hook is lifted out of the catch, letting it onto the wheel again.



It is necessary that while one wheel is being added to, the next wheel should not move. For this purpose the first stroke adds the first, third and odd orders to the numbers on the table, second, fourth and even orders, the odd orders being held firm by a clamp not shown. Meanwhile the rod *e* has been moved, so

that the drivers belonging to the even orders are not released as the carriage comes back, but those belonging to the odd orders, so that at the next stroke the even orders are added to the odd ones, and the number on the table-wheels printed; every two strokes of the carriage giving a new term of the table.

On each wheel between the teeth and cams are two grooves. The two slips *f* and *g* rest in these grooves, being held there by light springs. The pin *k* is so arranged that, when the wheel reads nine, it will be under the first slip *f*, holding it up; and as it passes from nine to zero it drops the slip *f*, raises and drops the slip *g*. To each wheel there is an arm H, to which the catch *m* is attached, the catch resting on the teeth of the wheel. This arm would be drawn back by a spring, but is held by two catches *p* and *q*. If the catch *p* is drawn, the arm will be held by *q* only, and if *q* is then drawn it will spring back, the catch falling over the next tooth. The slip *f* of each wheel is connected with the catch *p* of the wheel of the same order in the next decimal place higher, and the slip *g* with *q*. Each arm is connected by the lever *s* with its own slip *g*, so that it will draw it out when it springs back. As each nine on the wheel A comes to the point E, the slip *f* is pushed out, and the catch *p* to the next place B drawn; and as the zero comes to E, the slip *g* is pushed out, the catch *q* drawn, and the arm over B is sprung, drawing with it the catch *q* of the next place higher, C, but not releasing the arm at C, as it is still held by *p*. *p* will, however, be drawn, if B stands on nine, and both arms sprung, as it should be, for if the arm over B is released it indicates that one is to be added to it, and if it is already nine the addition of that one will make it necessary to carry one to C also. If C is nine, one must be carried to D, and so on; one must be carried to the first wheel which is not nine.

This is all done during the addition, after which and during the return of the carriage, the cam K brings all the arms back that are up, adding one to each wheel whose arm is up.

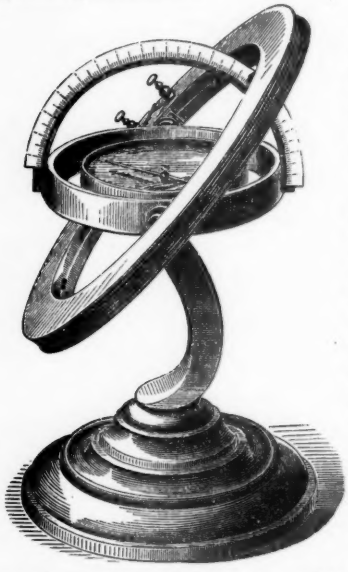
The entire printing part, as well as some details of framing, gearing, etc., are omitted from the accompanying sketch, which is meant merely as an outline drawing showing the principal parts only.

The size of a completed machine would vary with the capacity. An engine of the same capacity as that of Scheutz, would be three feet long, twelve inches high, and eight inches wide. The cost is estimated at from two to three thousand dollars.

Cambridge, June 5, 1871.

ART. XVI.—*A New Form of Galvanometer;* by JOHN TROWBRIDGE, Assistant Professor of Physics, Harvard College.

IN the tangent galvanometer the plane of the coil standing perpendicularly to the plane in which the needle moves, the needle is deflected by the action of the current passing through the coil upon the current circulating in the magnet; the magnet being considered a solenoid according to Ampère's theory. The tangent of the deflection measures the intensity of the current. The defects of the tangent galvanometer are well known. The poles of the needle in being repelled are removed from the field of the current and consequently with currents of great intensity the tangents are not closely proportional to the strength of the currents; the delicacy varying as the differential of $I=\tan \vartheta$, or $\frac{dI}{d\vartheta} = \sec^2 \vartheta$. When the ratio of the length of the needle to the diameter of the coil is a very small fraction, the tangents, however, are closely proportional to the corresponding intensities.



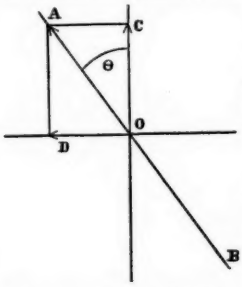
In Gaugain's galvanometer where the plane of the current is placed at a short distance from the axis of the needle, the intensities are directly proportional to the tangents of the deflections.

A mathematical investigation of the effects of electric currents on the magnetic needle, the plane of the current having different obliquities with regard to the horizontal plane in which the needle moves, led me to devise the following form of galvanometer:

A magnetic needle is placed at the centre of a circular current, the plane of the current at first being horizontal. In this position the needle is unaffected by the current, and is acted upon merely by the earth's magnetism. We now turn the plane of the current about a horizontal axis passing through the center of the needle as in the figure; A B representing the

plane of the coil in its new position, inclined at an angle of $90° - \vartheta$ to the horizon.

It will be readily seen that if A O represents the intensity of the current passing through the coil, O C will be the component that will deflect the needle; but $OC = AO \cos \vartheta = I \cos \vartheta$. The intensities will therefore be proportional to the cosines of the inclination of the plane of the current, measuring the angle from the vertical O C.



The instrument with which I experimented had the following dimensions: The diameter of the circle around which the current passed was twelve inches, and the length of the needle 1·4 inches; it was provided with long aluminum pointers. The inclinations of the plane of the current were read from a vertical scale perpendicular to both the plane of the current and to the plane in which the needle moved.

The manner of experimenting was as follows: The resistance of the battery—one Daniell's cell—having been determined with care, and also the resistance of the circuit, the instrument was first used as a tangent galvanometer with the plane of the current vertical.

Resistances from one up to ten ohms were introduced into the circuit, and the deflections noted; then with a constant resistance the angle was noted through which it was necessary to turn the plane of the current until the same deflection of the needle was obtained as in the cases where the instrument was used as a tangent galvanometer with varying resistances.

The following table gives the results obtained:

Ratio of Intensities	Angles of Deflection.	Ratio of Tangents.	Error.	Angles of Inclination.	Ratio of Cosines.	Error.
·076	18° 30′ / 75° 52′	·090	·014	85° 30′ / 0°	·078	·002
·142	32° 15′ / 75° 52′	·158	·016	82° / 0°	·139	·003
·200	41° / 75° 52′	·226	·026	78° 45′ / 0°	·195	·005
·333	54° 35′ / 75° 52′	·354	·021	70° / 0°	·342	·009
·400	15° / 32°	·428	·028	65° / 0°	·422	·022
·529	14° 30′ / 25° 30′	·542	·013	57° / 0°	·544	·015
·692	18° 30′ / 25° 30′	·701	·009	47° 45′ / 0°	·672	·020
·810	21° 30′ / 25° 30′	·825	·015	38° 15′ / 0°	·785	·025

It will be noticed that with large deflections the ratio of the cosines is nearer the ratio of the intensities than the ratio of the tangents. With smaller deflections, however, the ratio of the tangents is nearer that of the intensities than the ratio of the cosines. In the expression $I \cos \vartheta = CO = \tan \vartheta'$,

or $I = \frac{CO}{\cos \vartheta} = \frac{\tan \vartheta'}{\cos \vartheta}$, if we differentiate I with respect to ϑ we obtain

$$\frac{dI}{d\vartheta} = \cos \vartheta \frac{d.\tan \vartheta' + \sin \vartheta \tan \vartheta'}{\cos^2 \vartheta}$$

It will be seen that the delicacy varies inversely as the cosine of the inclination decreases, or in other words, as the angle of the plane of the current with the vertical increases; the vertical component of the intensity increases while the horizontal component decreases. This vertical component thus renders the needle less sensitive to the horizontal component and dips it. By diminishing the length of the needle, and providing it with long pointers, and also increasing the diameter of the circle around which the current passes, the effect of the vertical component can be lessened.

With large deflections, therefore, this instrument appears to give closer results than the tangent galvanometer; and therefore supplies a deficiency in the latter instrument. By the cosine galvanometer many determinations of the intensity of the same current can be made by forming a table of the values of the cosines of different angles of inclinations in terms of the deflections of the needle, which currents, with a known resistance interposed produce. In the tangent galvanometer but one determination can be made.

Irrespective of the accuracy of this method, the instrument can be viewed as supplying a break in the literature of the subject. We have now in addition to the tangent galvanometer and the sine galvanometer, a cosine galvanometer.

My thanks are due to Prof. Cooke, of Harvard College, for the generous use of his apparatus for electrical measurements.

ART. XVII.—*Notice of some new Fossil Mammals and Birds, from the Tertiary Formation of the West;* by O. C. MARSH.

IN addition to the species of extinct Mammals described in the last number of this Journal, page 35, the Yale party, during their investigations in the Rocky Mountain region, discovered several others of interest, which are here briefly characterized. The remains of a number of fossil Birds were also found, and a

preliminary notice of the more important specimens is included in the present article.

Arctomys vetus, sp. nov.

Remains of Rodents are very rare in the Green river Tertiary basin, although not uncommon in the more recent strata, east of the Rocky Mountains. A small species of the genus *Arctomys*, represented by a nearly perfect lower jaw, and other remains, was discovered during our explorations on the Loup Fork river. This species was only about one-third the size of the modern *Arctomys monax* Gm., and may at once be distinguished from that rodent by the lower incisors, which have on the anterior surface a shallow median groove. The molar teeth of the lower jaw have essentially the same composition as those of the larger species.

Measurements.

Length of lower jaw from condyle to base of incisor,	17·75	lines.
Antero-posterior extent of four lower molars,	6·5	"
Depth of lower jaw below first molar,	4·5	"

The specimens on which the species is based, were found by Mr. J. W. Wadsworth and the writer, in the Pliocene beds, on the Loup Fork, in northern Nebraska.

Geomys bisulcatus, sp. nov.

Another extinct Rodent, about the same size as the preceding species, is indicated by several fragments of jaws and teeth, found in the same Pliocene Tertiary beds. The incisors of the lower jaw in this species have the anterior face broad and flat, with the external angle acute. They extend backward under the entire molar series. The latter has a very similar composition to the molars of the recent *Geomys bursarius* Shaw, and the two species may eventually prove to be nearly allied. The upper incisors, likewise, are similar. On their anterior face there is a deep, rounded groove, with its lowest part just outside the median line. Near the inner angle, also, of each incisor, there is a second, very fine, sharp groove. The external front angle is rounded, and the lateral face but slightly convex. The premaxillary suture forms externally an obtuse angle, with the apex forward, near the posterior face of the incisor. In both jaws, the incisors are deeper than wide.

Measurements.

Transverse diameter of upper incisor,	1·6	lines.
Antero-posterior extent,	2·	"
Depth of skull at premaxillary suture,	6·	"
Length of lower incisor on arc of curve,	15·	"
Tranverse diameter at apex,	1·5	"
Depth of lower jaw below first molar,	5·6	"
Antero-posterior extent of first three lower molars,	3·5	"

The only known specimens representing this species were found by the writer in the Pliocene strata, near Camp Thomas, on the Loup Fork river.

Sciuravus nitidus, gen. et sp. nov.

A very small extinct rodent of much interest is indicated by a portion of a left upper jaw, enclosing the last three molars, which was one of the treasures secured by the Yale party last autumn in the Tertiary beds of the Green River basin. The teeth preserved have apparently a near resemblance to those of the *Sciuridæ*, and hence the present fossil may be referred provisionally to that group. The genus is apparently distinct from any known, and will be more completely defined in the full description. The upper molars are composed essentially of two pairs of tubercles, with a minute intermediate cone on the outer edge. There is a strong basal ridge in front, and the inner margin is bifid. The species was about the size of the common brown rat, *Mus decumanus*.

Measurements.

Length of part of upper jaw, enclosing the three posterior molars,	3·4 lines.
Antero-posterior extent of antepenultimate upper molar,	1· "
Transverse extent of same,	1· "

This unique specimen was discovered by the writer at Grizzly Buttes, near Fort Bridger, Wyoming.

Sciuravus undans, sp. nov.

The present species was somewhat larger than the preceding, but probably a near ally. A single specimen only can now with certainty be referred to it, and a discussion of its exact affinities must be reserved for another occasion. The fossil in question is part of a right lower jaw containing the incisors and first three molars, all in excellent preservation. The incisor extends below the entire molar series. Its anterior surface is smooth, and somewhat convex, and the inner face, where the two teeth meet, is marked by a succession of delicate wave-like impressions. The tubercles of the molars are more prominent than in those of the last species.

Measurements.

Length of portion of lower jaw, containing first three molars,	3·5 lines.
Transverse diameter of third lower molar,	1· "
Transverse diameter of lower incisor,	·6 "

This specimen was found by the writer at the same geological horizon, and near the same locality that afforded the species last described.

Triacodon fallax, gen. et sp. nov.

A small extinct mammal of much interest, is indicated by a premolar tooth, and possibly by some additional remains, collected in the lower Tertiary beds of Wyoming. The tooth appears to be the last premolar of the right lower jaw, but differs so widely from the corresponding premolar in any known species, as to render the nature of the animal to which it belonged more or less uncertain. The crown is triangular at the base, the outer and longest side being somewhat convex, and the other two nearly flat. The upper surface is composed of three triangular tubercles, one at each angle, the anterior being much the highest, and the inner one the smallest. This peculiar tooth resembles slightly the corresponding premolar in some of the Insectivores, and is likewise similar in some respects to those of certain Marsupials, but further remains will doubtless be necessary to determine its true zoological position. The present species was probably about two thirds the size of the North American opossum.

Measurements.

Antero-posterior diameter of lower premolar,	2·25 lines.
Transverse diameter of same,	1·95 "
Height of anterior tubercle,	2·8 "
Height of posterior tubercle,	1·6 "
Height of inner tubercle,	1·75 "

All the specimens supposed to pertain to this species were found by J. M. Russell and the writer, at Grizzly Buttes, near the base of the Uintah Mountains.

Canis montanus, sp. nov.

The presence of a large Carnivore in the fossil fauna of the Green River Tertiary basin, which could with comparative certainty be predicated upon the discovery there of so many extinct pachyderms, was clearly established by our party; although the evidence at present rests on remains more or less fragmentary. Those already known consist of a last upper premolar tooth in good preservation, a Canine, wanting most of the crown, and a number of the larger bones of a skeleton, all apparently of the same species, but pertaining to three individuals, differing somewhat in size. These various remains indicate an animal considerably larger than the recent Gray Wolf (*Canis occidentalis*), and one probably belonging to the same family. The last upper premolar in the present extinct species is robust, has a short compressed crown. The principal cusp is conical, with sub-acute edges, the anterior being about twice the length of the posterior. Behind the main cusp there is a large triangular tubercle, with its apex exterior to the fore

and aft axis of the crown. In the canine tooth, the base of the crown forms a broader oval than in most of the recent *Canidæ*.

Measurements.

Antero-posterior diameter of last upper premolar,	9· lines.
Greatest transverse diameter of same,	4·25 "
Height of main cusp,	6· "
Height of posterior tubercle,	3·75 "
Antero-posterior diameter of canine at base of crown,	7· "
Transverse diameter of same,	5· "

The above specimens were found by H. B. Sargent and the writer, at Grizzly Buttes, Western Wyoming.

Vulpavus palustris, gen. et sp. nov.

A second, much smaller carnivore is indicated by several upper molar teeth, and other fragmentary remains, found during our explorations in the same Tertiary deposits that yielded the preceding species. The specimens belonged to several individuals, all considerably smaller than a fox, and apparently having some affinities with that animal, although generically distinct. One of the best preserved of the teeth is a second, right, upper molar, which has a similar composition to the corresponding tooth of the common Red fox (*Vulpes fulvus* Desm.), but differs in the outline of the crown, which has the posterior side the longest, thus indicating a relative greater expansion at this part of the skull. The first upper molar, also, has a proportionally less fore and aft extent than the same tooth in the fox.

Measurements.

Length of portion of jaw containing last three upper molars,	10·5 lines.
Antero-posterior diameter of second upper molar,	2·35 "
Transverse diameter of same,	4· "

The specimens now representing this species were discovered by Dr. J. V. A. Carter, and the writer, near Fort Bridger, Wyoming.

Amphicyon angustidens, sp. nov.

Another extinct carnivore, about as large as the preceding species, and perhaps related to the same group, is represented by the anterior portion of a right lower jaw, containing the last three premolars, and the canine. The ramus is slender, but rather deep. The premolar teeth are low, and unusually compressed. All have a distinct tubercle in front of the main cusp, and the third and fourth have the posterior edge trifid. The present specimen agrees essentially in size with the corresponding jaw of *Amphicyon gracilis* Leidy, but the last premolar is less elevated, more compressed, and has the middle tubercle on the posterior edge much less developed than in that species.

Measurements.

Length of part of lower jaw containing four premolars,	9·5	lines.
Depth of jaw below last premolar,	5·	"
Width of jaw below last premolar,	2·1	"
Antero-posterior diameter of last lower premolar,	3·	"
Transverse diameter of same,	1·25	"
Height of crown,	1·8	"

This species was found by the writer, in the Miocene Shale, at Scott's Bluff, on the North Platte river, Nebraska.

Fossil Remains of Birds.

Since the beginning of the last year, when the first fossil Birds from this country were described by the writer,* but two additional species have been announced: an extinct Turkey, *Meleagris altus* Marsh (*M. superbus* Cope), from the Post-Tertiary of New Jersey,† and a Gannet, *Sula loxostyla* Cope, from the Miocene of North Carolina.‡ A special search was made by the Yale party last season for Bird remains, and a number of specimens were discovered, most of which were not sufficiently well preserved to admit of accurate determination. The few described below, although imperfect, are quite characteristic, and form an acceptable addition to the rich Tertiary fauna of the West, which has so long been deemed wanting in remains of this class.

Aquila Dananus, sp. nov.

An extinct species of Eagle, nearly as large as the modern Golden Eagle (*Aquila Canadensis* Cass.), is indicated by the distal portion of a left tibia, discovered during our explorations in the Pliocene beds of the Loup Fork river. The specimen shows, at its lower extremity, the peculiar fore and aft flattening, and the oblique, tapering supra-tendinal bridge over a deep canal, so characteristic of the recent birds of prey belonging to this genus. From the tibia of the Golden Eagle, evidently a nearly related species, the present fossil may readily be distinguished, aside from its inferior size, by the less concave inferior and posterior trochlear surfaces, and by the more prominent and well defined tubercle at the center of the ento-condyloid surface.

Measurements.

Width of condyles in front,	8·	lines.
Antero-posterior diameter of inner condyle,	5·25	"
Antero-posterior diameter between condyles,	3·3	"
Transverse extent of outlet of canal below bridge,	2·	"

* This Journal, vol. xlix, p. 205, 1870.

† Proceedings Philadelphia Acad. Nat. Sciences, 1870, p. 11, and American Naturalist, vol. iv, p. 317.

‡ Synopsis of Extinct Batrachia, &c., p. 236.

This unique specimen was discovered in July last by Mr. A. H. Ewing, in a Pliocene bluff on the Loup Fork river. The species is named in honor of Professor James D. Dana.

Meleagris antiquus, sp. nov.

A large Gallinaceous Bird, approaching in size the wild Turkey, and probably belonging to the same group, was a cotemporary of the *Oreodon* and its associates, during the formation of the Miocene lake deposits east of the Rocky Mountains. The species is at present represented only by a few fragments of the skeleton, but among these is a distal end of a right humerus, with the characteristic portions all preserved. The specimen agrees in its main features with the humerus of *Meleagris gallopavo* Linn., the most noticeable points of difference being the absence in the fossil species of the broad longitudinal ridge on the inner surface of the distal end, opposite the radial condyle; and the abrupt termination of the ulnar condyle at its outer, superior border.

Measurements.

Greatest diameter of humerus at distal end,	12·	lines.
Transverse diameter of ulnar condyle,	3·4	"
Vertical diameter of same,	4·	"
Transverse diameter of radical condyle,	4·25	"

The specimens on which this species is based were discovered by Mr. G. B. Grinnell, of the Yale party, in the Miocene clay deposits, of Northern Colorado.

Bubo leptosteus, sp. nov.

Several imperfect specimens of bird bones were found in the early Tertiary beds of the Green river basin, only one of which, however, the distal half of a left tibia, is sufficiently characteristic to suggest the near affinities of this species to which it pertained. This specimen shows that the tibia, when entire, was a slender, nearly straight bone, much compressed in an antero-posterior direction at its distal end, and having similar proportions to the same bone in the *Strigidæ*, or Owl family. The near resemblance is rendered especially striking by the entire absence of the osseous supra-tendinal bridge, which is wantin this group, and in a few other birds with which the present species is apparently less nearly allied. The fossil under consideration would indicate a species about two-thirds the size of the Great Horned Owl (*Bubo Virginianus* Bon.), the tibia of which it resembles in nearly all essential particulars. There is, however, no trace of a fibular ridge on the outer surface of the distal end, as in that species, or on the portion of the shaft preserved; which would seem to imply a generic difference between the two forms, and additional material will doubtless prove such to be the case.

Measurements.

Length of portion of tibia preserved,	15·	lines.
Width of condyles in front,	6·5	"
Transverse anterior diameter of inner condyle,	2·5	"
Transverse anterior diameter of outer condyle,	1·8	"

This specimen, the only known representative of the species, was found by the writer last autumn at Grizzly Buttes, near Fort Bridger, Wyoming.

Yale College, New Haven, June 12th, 1871.

ART. XVIII.—*Notes on the distribution of the Vegetation of Santo Domingo;* by W. M. GABB.

MUCH has been said and written on the singular phenomenon, exhibited on a grand scale in our western prairies as well as in South America and elsewhere, of large treeless areas, strongly circumscribed, and covered with grass. Innumerable theories have been advanced to account for the absence of forest growths over these tracts, and the entire absence of even isolated trees has been a cause of unlimited speculation. This is the more strange since it is found that when trees are artificially planted, they flourish, and the occupation of these tracts in the Mississippi region is covering them with vigorous groves.

Upwards of two years of residence in "the garden of the Antilles" has given the writer an opportunity of studying the matter here, as well as of making some general observations on the distribution of the vegetation of Santo Domingo.

To most persons who have never been in the tropics, the term presents a vision of tangled jungles, endless climbing vines, and waving palms. Few think of broad swelling prairies and smiling meadows as compatible with a landscape below the Cancer. But both exist in charming variety, not only in the favorite home of Columbus, but over much of our little known neighbor, the continent of South America.

On the Island of Santo Domingo, the grass and tree regions are sharply defined, and correspond in the main with certain geological features. First, the whole mountain region is covered with tree-growth to at least a little distance beyond its base. Second, the valley of the Cibao, the great valley occupying a fourth of the Republic of St. Domingo proper, and running east and west on the north side of the Island, is in the main a tree region, with scattered savannas, as will be described farther on. Third, the south side of the island, outside of the mountain tracts, is nearly equally divided between forest and prairie.

Observation proves that in each and every case the relation between the soil and its growth is constant. The mountains are composed of easily decomposable rocks, which produce a rich soil. This supports dycotyledonous trees of an infinitude of species, with a dense undergrowth in which climbing vines, some with trunks three and four inches thick, are the most marked feature. But there are tracts, more especially on the northern flanks of the range, where the soil is a red gravel. Here, without reference to altitude, (except that it does not extend into the plains) the forest growth is coniferous—a tall slender species of long leaved pine, and invariably, under the pines is a scattered growth of grass. The only other marked effect of altitude on the vegetation in these mountains is the almost invariable existence, above a height of say 2500 to 3000 feet, of dense thickets of a tall slender fern, which renders the higher peaks almost absolutely inaccessible.

The Tertiary rocks, which constitute the Cibao valley and northern range of mountains, never carry pine. The eastern half of the valley is covered in part with a very deep black mould, always bearing dense forests, and with a gravelly or clayey soil always covered with grass. This valley lies directly in the course of the trade winds; its eastern end, at Samaná bay, being open like a funnel to draw in the moisture-laden breezes from the Atlantic. As the current draws down the valley, confined by the hills on both sides, it deposits its vapors so liberally in the Vega, or eastern end, that by the time it reaches the middle of the valley, it is perceptibly dryer. The inevitable result is a striking change in the vegetation. The soil, which in the mountains would be pine lands, or in the Vega would make of this one continuous savanna of fifty miles long, here bears a straggling growth of low Acacias and Cacti. Among the latter, a Cereus of twenty to thirty feet high and an arborescent Opuntia often twenty feet high, are the most marked. In the more fertile soil, both on the lower hills and in the valley, lignum vitæ (Guayacan) abounds, and logwood (Campeachy) frequents the moist bottom. Throughout the Cactus and Acacia tracts, grass grows sparsely.

The mountains approach the coast, west of Santo Domingo city, leaving small plains only, until near the great bay of Ocoa. East of this broad spur is a strip of plains nearly thirty miles wide extending to the eastern end of the island. The underlying geology, and consequently the surface soil, is here divided into two well marked groups. In the Post-pliocene era, the coast line followed the present mountain base, and the mouth of the Jaina river was twenty-five or thirty miles farther northwest than at present. This stream runs through a region of hard rocks; and its débris, now spread over the country like a fan,

is consequently a coarse gravel, gradually changing into a clay or sand, as the distance from the old mouth and coast line increases. Still further, where shore influences fade out, the same strata are continued, but instead of appearing as a loose gravel, they become calcareous, and, in the then deep sea, change to beds of coral limestone.

The underlying gravels sands and clays are always covered with grass while the calcareous rocks make, as invariably, a tree region. In consequence of this, the whole coast, for a width of about ten miles near St. Domingo city, and gradually becoming wider eastward, is a great forest covering about two thirds of the plain. Mahogany grows only on calcareous soils, and this is thus the great mahogany-producing region of the Republic. It also abounds in logwood.

The same condition of the winds, though in a less degree than in the north, exists on the south side. Saybo is a rainy region, Azua is dry. About thirty miles west of Sto. Domingo, the region of cactus begins, the acacias straggling ten miles farther east. With the above mentioned species of Cereus and Opuntia, a small Echinocactus is most common here. Here again reappears the lignum-vitæ with considerable quantities of fustic.

I have not had an opportunity of examining the region northwest of Azua, which is infested by roving bands of Haytian marauders, but from the meager information I have been able to obtain, I am led to infer that there, there is no marked variation from the general rule of the rest of the country.

Throughout all the savannas, whether on the north or south side of the Island, almost every depression, and every watercourse is marked by its clump or line of trees; the spots being equally characterized by a richer soil, brought there by the surface drainage of rain waters. This, in connection with the other facts stated above, points to the inevitable conclusion, that the richer soils produce forest, and the poorer, grass growths. Independent of the tendency in the trees to monopolize the richer soil and kill out the grass by their shade, there comes in to the aid of the humble growths an important agency, which prevents or retards the spread of the forests which would otherwise inevitably overrun all the grass land in the end. This agency is fire. The edges of the tree tracts are as sharply defined as if attended by a careful gardener. The annual fires so scorch and burn up the smaller bushes, the advance guards of the larger trees, that it is doubtful, in the process of encroachment, which has the advantage.

ART. XIX.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XV.—*Descriptions of Starfishes and Ophiurians from the Atlantic coasts of America and Africa;* by A. E. VERRILL.

THE genus, *Goniaster*, as restricted by Dr. J. E. Gray in 1840, includes several beautiful species of starfishes, which are still very rare and imperfectly known. Dr. Gray named three species, without giving descriptions sufficient for their identification, all of which were from unknown localities, and two of them were apparently known to him only from the rude figures of Linck and Seba. I am unable to refer the two following species to either of the species named by him.

Goniaster Americanus, sp. nov.

Form pentagonal with deeply and regularly concave edges. Radii as 1 : 1·8. Rays considerably less than half the diameter of the disk, triangular, tapering, with slightly incurved sides. The disk is somewhat convex, especially at center, and covered with rather large, polygonal plates, which are separated by lines of pores, and on the rays by small groups and circular clusters of granules. The plates, unless supporting a spine, are closely covered with small polygonal granules, with a well-marked larger series around the edge; those that bear spines have the marginal granules and two or more series of the smaller ones around the base of the spine. In the center of the disk is a single spine, around this are five larger ones, each of which is the first in a row of 4 to 8 spines extending along the middle of the ray, but usually interrupted by plates destitute of spines; bordering the middle of the central row, on each side, there is a row of 5 or 6 similar spines; outside of these a row of 3 or 4 smaller spines; and beyond these usually 1 or 2 spines; thus the middle region of each ray has a broad-oval group of spines, broadest toward the center of the disk.

The groups of spines are separated by depressed interradial zones, destitute of spines; in each of these there is a rounded plate, outside of and alternating with the spines of the central pentagon; beyond these there are, in four of the zones, a pair of rather large plates, in contact by their straight inner margins; in the fifth zone a large convex madreporic plate takes the place of these. The upper marginal plates are 14 to each interradial margin, about as long as broad, very convex, the three median ones largest, and rising into two blunt tubercles or spines, which are united at base; most of the others, except the penultimate ones, bear a single, conical, blunt tubercle, decreasing in size toward the end of the ray. Lower mar-

ginal plates 22 to each margin, the median ones smooth, convex, nearly twice as high as wide, the lateral edges straight and in contact; those toward the ends of the rays become rounded, about as broad as high, and the last four or five plates bear single, stout, blunt tubercles. The marginal plates are surrounded by either one or two rows of granules. The plates of the lower surface are closely covered with polygonal, round-topped granules, smallest toward the edges of the plates; a few plates near the mouth bear one or two stout central tubercles; others near the ambulacral grooves, and especially toward the margin, have a smooth central area, perforated by one or more small pores and bearing as many peculiar pedicellariæ, which consist of two, slender, spatulate, or spoon-shaped blades, often curved laterally, and usually seen widely open, when they are received into grooves or pits in the plate, exactly fitted to their forms. Similar pedicellariæ of smaller size exist at the base of many of the dorsal spines.

The interambulacral plates bear, at their inner edges, a row of about 4, prismatic, nearly equal, blunt, spines; and outside of these an irregular crowded group of 4 to 6, stouter, but scarcely longer, blunt spines, the outer ones shorter; these form three or four irregular rows.

Radius of disk 1·45 inches; of rays 2·60; length of largest dorsal spines ·30; diameter ·20 of an inch. Color of the dried specimen yellowish brown, when fresh bright red.

Off Charleston, S. C., from the mouth of a Black-fish,—Prof. C. U. Shepard.

Goniaster Africanus, sp. nov.

Depressed, pentagonal, with shorter rays and less concave edges than the preceding species. Radii as 1 : 1·6. Rays broad triangular, obtuse, the last upper marginal plates larger than the others and more swollen. Plates of the upper surface smaller and more numerous than in the preceding, and more coarsely and irregularly granulated. Spines smaller, but much more numerous, the clusters scarcely separated and covering most of the surface; the median row of the rays, with 10 to 12 spines; the first laterals with about as many; the second laterals with 5 or 6; the third, with 3 to 5. Upper marginal plates 10 to each interradial margin, smooth, convex, the median ones narrowest, higher than broad; the last one largest, rounded, very convex; none bear spines or tubercles. Lower marginal plates 18 to each margin, smooth, convex, destitute of tubercles, except occasionally a minute one on some of the last plates. Ventral plates covered with very unequal rounded granules, those on the central part much larger than the others, in the form of small round tubercles. No pedicellariæ observed. Interambulacral

spines arranged much as in the preceding, but more slender and less numerous, the outer ones forming two or three rows.

Radius of disk 1·06; of rays 1·70; length of longest spines ·17; diameter ·12 of an inch. Color of dried specimens light orange-red.

West Coast of Africa,—Capt. W. W. Hall. Received from the Peabody Academy of Science, Salem, Mass.

Amphipholis abdita, sp. nov.

Disk small; arms much elongated, about 12 times the diameter of the disk, of nearly uniform diameter throughout the greater part of their length.

Six mouth-papillæ in each angle of the mouth, and two to four additional small rounded papillæ, or tentacle scales, near the extreme outer angle. Two of the mouth-papillæ on each side are placed close together, at about the middle of the edge of the jaw; the outer of these, which is about twice as wide as the inner, is flat, scarcely longer than wide, with the end obtusely rounded or truncate; the inner one is scarcely wider than thick, oblong, rounded at the end; in one case these two papillæ are united together. The third mouth-papilla is stout and rounded, obtuse, larger and longer than either of the others, separated from them by a considerable interval, and brought close to the tooth at the end of the jaw, beyond which it projects inwardly and downwardly.

The mouth-shields are long-oval, narrowed outwardly, the outer part of the lateral edges being nearly straight, the outer end rounded, the inner end broadly rounded. Side mouth-shields triangular with the three edges concave, the inner ends not united, the surface finely granulated. The lower arm-plates are separated by the side plates; the two first are longer than broad, pentagonal, the inner end forming an obtuse angle, the outer edge straight; the two next are about as wide as long, squarish, with the corners rounded or truncate; the following ones are broader than long, somewhat octagonal, the outer and inner edges longest and nearly straight; beyond the middle of the arm they are again pentagonal, with an inner angle. On the first five joints there is usually only a single pair of tentacle-scales, which are small and rounded; on the succeeding joints there are generally two pairs, one of them being considerably smaller than the other.

Arm-spines three, on all the joints except the first, which has but two; they are thickened at base, gradually tapering, blunt at tip, subequal, the lower ones a little curved downward; length about equal to width of lower arm-plates. The upper arm-plates are transversely subelliptical, with the outer edge well rounded, the inner edge slightly prominent or angular in

the middle, and a little concave to either side, so that the lateral portions are somewhat narrowed; the plates generally touch each other, but scarcely overlap, unless close to the base of the arms. The upper surface of the disk has been destroyed in the only specimens seen. Diameter of disk about ·38 of an inch; length of longest arms (broken at the ends) 4 inches.

Color in alcohol uniform light yellowish, when living tinged with greenish.

Off Thimble Islands and Savin Rock, near New Haven, in 3 to 6 fathoms, muddy bottom, living buried in the mud with one arm thrust out of its burrow.

I have been aware of the existence of this species for several years, having on several occasions dredged a single detached arm, but it was not until last autumn that I succeeded in obtaining a specimen with the disk, and even in this the covering of the dorsal side was destroyed.

It is somewhat allied to *A. gracillima* (Stimpson), of S. Carolina, and has similar habits. The latter has more slender arms, four or five arm-spines, and different mouth parts.

Ophiophragmus Wurdemanni Lyman, Catalogue, p. 132.

This species is common at Fort Macon, N. C., living in the sand at low water, where it was obtained by Dr. A. S. Packard and Dr. Elliott Coues. It varies considerably in color, some specimens being yellow, with few dark markings; in others the dark brown bands predominate. The disk is brown above, lighter below.

The arms are very long and slender. One of the largest has the arms 6 inches long, and the disk ·4 in diameter. The scaling of the disk is variable, and generally coarser than in Mr. Lyman's type specimens. The radial shields are usually in contact. The under arm-plates, near the base of the arms, are emarginate and slightly bilobed.

ART. XX.—*Notice of the Meteoric Stone of Searsmont, Maine;* by CHARLES UPHAM SHEPARD, Mass. Prof. of Natural History in Amherst College.

FOR the particulars concerning the fall of the Searsmont meteorite I am indebted to Mr. E. B. Sheldon, postmaster of the adjoining village of Searsport, and to the Republican Journal of Belfast, Maine, of Thursday, May 25th.

Mr. Edward Burgess of Searsmont furnished the short notice contained in the newspaper. He states that the fall took place in the southern part of the town, at about 8 o'clock on Sunday morning, the 21st instant. "There was first heard an explo-

sion, like the report of a heavy gun, followed by a rushing sound resembling the escape of steam from a boiler. The sound seemed to come from the south, and to move northwardly. The stone fell in the field of Mr. Bean, the flying earth being seen by Mrs. Buck, who lives near. The hole that it made was soon found and the stone dug out. It was quite hot and so much broken as to be removed only in pieces. The outside shows plainly the effect of melting heat. It struck with such force as to penetrate the hard soil to a depth of two feet."

The following is the substance of Mr. Sheldon's letter. Mr. Luce, who dug the stone, tells me he reached the spot about fifteen minutes after it struck, when he found the fragments still quite warm. The largest piece weighed two pounds. All together, the pieces amounted to twelve pounds. They emitted the odor given off by stones violently rubbed together. The hole produced by the descent was vertical in its direction, and two feet in depth. The character of the soil was a hard, coarse gravel; and the shattering of the stone was produced by its finally meeting three large pebbles, (each about four pounds in weight) in the course of its descent. "Mrs. Buck, who saw it fall, or rather saw the scattering of the soil on its entering the ground, was reading at the time in the house, distant about thirty rods from the spot. The time was 15 minutes past eight. She first noticed a report about as loud as that of a heavy gun, or of a rock-blast, such as they hear from a lime-quarry situated about a quarter of a mile distant. This was followed by a rumbling noise, as of a number of carriages passing over a bridge. She rose and looked out from a back door, then re-crossed the room to the front door, where, after the lapse of about ten seconds, she saw the dirt in motion from the contact of the stone with the earth. She thought it must have been nearly two minutes from the first report, until the stone struck the ground. No one went to the place for 20 or 25 minutes. The report was heard in Warren, twelve miles to the southwest; likewise a hissing sound as of escaping steam. No report or sound was heard in Searsmont village, three miles to the northeast."

Through the kind assistance of Mr. Sheldon, I am in possession of the largest remaining mass of this meteorite. Its weight is two pounds. Fully one-half of its surface is coated with the original crust. Its shape would seem to denote an oval, subconical figure in the original mass, with a flattish base, so as on the whole to have approached the shape of the famous Duralla (India) stone, (Feb. 18, 1815), now preserved in the British Museum.* The coated part of my specimen, which

* Of which I possess an excellent model, presented me while that stone was still in the collection of the East India House.

corresponds to a portion of what constituted the base of the supposed cone, differs in shape and color from the two oval undulating sides, which make therewith angles of between 60° and 70°. The broadest of these sides (above three inches in length) where it meets the base, forms a blunt rounded edge, is obscurely striated vertically to the intersection, and shows a slight thickening about the edge, as if matter had been swept over from above and accumulated somewhat on the under side. Nothing is plainer than the distinction in character between the upper sides and the base. The crust of the latter is perfectly black, more thoroughly fused, with a blebby, somewhat glassy, reticulated surface, whose lines are without any order; while the upper surfaces are more even and almost destitute of the blebby and veined appearance. Feeble striæ are visible near the basal side, all of which are perpendicular to the same. The color of the upper surfaces is brownish black; and these are wholly without luster.

The thickness of the crust is more than double that found in any stone belonging to my collection,—amounting at least to one-sixteenth of an inch. The stone is rather below the average in respect to frangibility. The color is bluish-white, and remarkably uniform, except from feeble stains of peroxide of iron, and from silvery white, metallic points, produced by the meteoric iron. More than half the stone is in the form of rounded grains, mostly with roughened or drusy surfaces, and of a size rarely exceeding mustard seeds. Between these, and often partially coating them, is a fine grained subcrystalline white, or grayish-white mineral, which I take to be chladnite. It is rather loosely coherent, and without visible crystalline structure. Indeed, as seen by the microscope, it is often porous, reminding one of the siliceous skeletons obtained in fluxing certain silicates in blowpipe experiments. This white mineral may form a quarter or more of the stone.

The rounded globules are bluish-gray, rarely with a faint tinge of yellow, vitreous in luster and translucent, with two imperfect oblique cleavages. On the whole, they resemble the unaltered grains of boltonite more than any of our terrestrial minerals; and differ only in their greater tendency to assume the globular figure.

Minute points of bright meteoric iron are very thickly scattered through the mass. A few grains of troilite, the largest of the size of small kernels of Indian corn (maize), likewise present themselves; together with a single blackish mass of similar dimensions, which on being touched with the point of a knife was found to be soft, and left a bright metallic streak. It is probably a plumbaginous aggregate. Sp. gr. of the aggregate = 3·626.

In general character, it approaches most nearly to the stones of Quenggouk (Pegu, India) that fell Dec. 27, 1857, differing from them in having more of the fine whitish gangue, and in possessing a thicker and more blebby crust. It also presents points of resemblance to the Aussun (France) meteorite of Dec. 9, 1858; but the latter has a much thinner crust, a darker colored general basis or gangue, much larger globules, and at the same time, it is a firmer stone.

There is even an internal similarity between the Searsmont meteorite and that of Duralla. They approach each other in the thickness and general character of the crust; but the whole of the latter is darker, and the regularity in the shape of its globules is less marked.

Should I succeed in recovering a portion of the now widely scattered fragments of this interesting stone, I shall enter upon a more detailed examination of its character.

Letter to the Editors from Dr. B. A. Gould, *Director of the Cordoba Observatory, dated Cordoba, April* 26, 1871.

[Concluded from page 80.]

The magnificence of the Milky Way in this vicinity is indescribable, surpassing the Pleiades or the Præsepe in richness, and exhibiting numerous huge clusters, the sight of which through the Tolles telescope evokes exclamations of astonishment and delight from every beholder, young or old, whether with or without astronomical information. Keen as was my desire for a photographic equipment before leaving home, it has been a hundred-fold increased since I began the survey of this most gorgeous of all the regions of the sky. Even yet I have not abandoned some hope that the friends of astronomy at home may be disposed to provide means for some permanent photographic record of these magnificent groups and splendid double stars. The transparency of the atmosphere would greatly reduce the needful time of exposure, and it gives peculiar opportunities for the success of the photographic method in other respects.

The news from the Eclipse-observers—so long and anxiously expected—is just beginning to arrive; our mail facilities having been sadly interfered with by the quarantine, established at Rosario, which has for more than two months placed an absolute interdiction upon all personal communication with Buenos Aires. From such accounts of the eclipse as have yet come to hand, it would seem that the results tend to confirm the doctrine that the corona is of a composite character, although this idea met with such opposition prior to the eclipse; but that my other observation, to which I attribute a good deal of importance, viz:—the change of outline in the more conspicuous and external portion of the phenomenon during the period of totality was neither verified nor the reverse, since the unfavorable atmospheric influences appear to have cut off this part of the exhibition at those few stations from which accounts have been received here. You may imagine with what eager interest we are awaiting the arrival of more detailed accounts from Europe or the United States.

You have unquestionably heard of the fearful pestilence which has been desolating the capital of this republic. The yellow fever, which broke out there at the close of January, has made such ravages that all commerce has

been suspended, banks and public offices are closed, and not less than ⅘ths of the population have fled to the suburbs. The gates of the only practicable road to the interior of the country have been closed by the absolute interdiction of travel which the municipal authorities of Rosario have succeeded in imposing, notwithstanding the fever appears to have been purely local, and there is no authentic account of the disease being communicated in a single case at the distance of five miles from the center of the city. A few fatal cases have occurred where the patient left the city after contracting the infection, but the great majority in such cases have recovered. Within the city limits of Buenos Aires, the mortality has been terrific, reaching at one time a daily average of 500 in a population reduced, by the flight of all who could escape, to a number probably not much, if at all, exceeding 50,000.—The official reports give a total of more than 15,000 deaths from yellow fever since the middle of February up to which time the fatal cases were restricted to a single ward and seldom amounted to more than eight or ten a day. At first, too, the better classes escaped, but ultimately all classes were attacked indiscriminately, and in all parts of the city. The disease is at present on the wane quite rapidly, and the telegraph officials are returning to their posts, so that we are in daily receipt of more encouraging accounts.

Among the minor evils of this fearful epidemic have been the financial irregularities from which not only all government institutions, but likewise all commercial and social relations, have suffered. Even the Observatory has not escaped its share of these, although all public officers have done their best in its behalf, and have shown a most gratifying and encouraging interest. The citizens and authorities of Cordoba, too, have shown themselves desirous of aiding us on all occasions and in every way, and the Observatory has suffered decidedly less than other public institutions in this exceptional condition of affairs.

A scientific faculty is now organizing in this ancient university; and the professors of Chemistry, Botany, and Mineralogy have arrived from Germany and are already engaged in their respective researches. The flora of this region seems to be a characteristic one, but to contain a peculiarly small number of species. The professor of botany is making extensive collections, from which our own museums will doubtless profit in good time.

Before this reaches you, I trust that not only will the observatory have been completed by the erection of the portion which left the United States in January and is probably at this very moment in the waters of the River La Plata, awaiting the reopening of the port of Buenos Aires, but also that our regular zone-work will have fairly begun. Still we have become inured to delays, and the vigorous prosecution of the Uranometry leaves no time to be consumed in lamentations.

If you know of any good man who has a few thousand dollars which he is disposed to contribute to the advancement of Astronomy, please tell him that there are few if any ways in which they could be so effectively bestowed, as in securing photographs of the Southern sky at the present time. I have with me here the object glass with which Mr. Rutherfurd took his magnificent photographs of the Moon, the Pleiades, the Præsepe and the cluster in Perseus, and am only in need of a mounting for the telescope, chemical equipments and a trained photographer, all of which a little money would enable us to secure without delay.—With these appliances, more astronomical material of the sort, to which the photographic method is specially adapted, could be collected in two years, than without it in twenty. And this material, once secured, can be elaborated at any subsequent time and the work repeated by any number of independent investigators.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Spectrum of Uranus.*—The spectrum of Uranus was first observed by Secchi in 1869. He noticed a complete absorption of the yellow rays, while there were two large black bands, one in the green and the other in the blue. The band in the blue was less refrangible than F; that in the green was near E. Mr. Huggins has observed the spectrum of this planet with a 15-inch refractor by Messrs. Grubb & Son, and has determined the existence and position of six strong absorption bands. The positions of these bands were measured by means of the micrometer and by comparison with the spectra of terrestrial substances. The strongest of the lines has a wave length of about $0{\cdot}000544^{mm}$. The others corresponded respectively to wave lengths of about $0{\cdot}000572^{mm}$, $0{\cdot}000595^{mm}$, $0{\cdot}000618^{mm}$, $0{\cdot}000486^{mm}$ and $0{\cdot}000634^{mm}$. The band at $0{\cdot}000572^{mm}$ is nearly as broad but not as dark as that at $0{\cdot}000544^{mm}$. The band $0{\cdot}000486^{mm}$ corresponds to F of the solar spectrum. The author found that the absorption bands of Uranus could not be ascribed to the presence of carbonic acid, and also that there is no strong line in the spectrum of the planet which corresponds to the strongest of the air lines, the double line of nitrogen, although the two planetary bands $0{\cdot}000595^{mm}$ and $0{\cdot}000618^{mm}$ very nearly coincided with bright lines of air.—*Proceedings of the Royal Society, and Nature, for June 1st*, 1871.

W. G.

2. *On the application of the Spectroscope to the measurement and comparison of the intensity of colored light, and to the quantitative determination of Coloring Matters.*—Vierordt has succeeded in applying the spectroscope to quantitative determinations of considerable interest and importance. To determine the relative intensity of the light of different portions of the spectrum, the author employs a spectroscope provided with the ordinary scale telescope. The scale itself is however removed, and a slit arrangement similar to that of the collimator substituted. This slit is illuminated by a constant source of light, which serves as the standard. The intensity of this light may be varied either by varying the width of the slit, by changing its distance from the source of light, or by the employment of smoke-tinted glasses as absorbing media. The image of the slit being reflected from the surface of emergence of the prism appears superficial upon the spectrum, and when the intensity of the white light from the constant source is sufficiently intense, the spectral color at a given point will disappear. If now the intensity of this light is diminished gradually, a point will be arrived at for which the parts of the field of view illuminated by the pure spectral colors can no longer be distinguished from the corresponding part illuminated at the same time by the spectral colors, and by the faint white light. It is to be borne in mind that if the dark lines in the spec-

trum are vertical, the white image of the slit occupies only a portion of the central line of the spectrum, so that the pure spectral colors admit of direct comparison with those which are diluted with superficial white light. The principle of measurement depends therefore upon the capacity of the eye to distinguish differences of intensity of light of different colors. For the description of the apparatus employed and the details of the method, we must refer to the original paper. The author describes, however, one part of the apparatus, which we shall here notice as a valuable addition to the spectroscope when used for other purposes. This consists of a moveable plate carrying an adjustable slit, which is introduced into the eye-piece of the observing telescope, so that the plane of the slit coincides with that of the image. The slit may be made to traverse the whole field of view, by means of a screw; in this manner the whole spectrum may be excluded from view, with the exception of a given narrow portion. This arrangement enables the observer to examine a limited part of the spectrum for a long time without fatigue to the eye, and is of special use in examining faint positive* spectral lines.

In another paper the author points out a method of applying the spectroscope to the quantitative determination of coloring matters. The moveable plate which forms one half of the slit of the collimator is divided into two portions, each of which can be moved parallel to itself by a micrometer screw with divided head. When the two slits are of exactly equal breadth, the upper and lower halves of the spectrum will have the same intensity. If one of the slits, for example the upper, has a colored glass or other absorbing medium placed in front of it, the spectrum will be divided into two halves of unequal intensity. If now the other slit be narrowed gradually by means of the screw, the intensity of the light will gradually diminish until it becomes exactly equal for the two halves of the spectrum at a given part or region of color. The equalization of the light in the two halves of the spectrum is quickly produced, and in this manner the ratio between the quantity of light transmitted through the colored plate and the original intensity of the light is easily expressed in percentages. If C represents the degree of concentration of a colored solution, E its coefficient of extinction and A the coefficient of absorption of the dissolved active substance, we have $C=AE$. Hence the degree of concentration of a solution may be found by simply measuring its coefficient of extinction, provided that the coefficient of absorption of the dissolved substance has been determined once for all. The author promises hereafter a work on the application of the spectroscope to quantitative chemical analysis.—*Die Anwendung des Spectral-Apparates für Messung und Vergleichung der Stärke des farbigen Lichtes, Tübingen*, 1871; *Berichte der Deutschen Chem. Gesellschaft, 4ter Jahrgang*, No. 6, p. 327.

W. G.

* To avoid circumlocution, it seems desirable to employ the terms positive and negative, to denote respectively bright or dark lines or bands.—W. G.

3. *On the heat of neutralization of organic and inorganic bases soluble in water.*—J. THOMSEN in Copenhagen, has published the principal results of a recent investigation of the quantities of heat evolved in the neutralization of different bases of the same acid. These researches have led to the remarkable result that the so-called hydrates of the oxides of K, Na, L, Tl, Ba, Se, Ca and Mg evolve on saturation with sulphuric acid the same quantity of heat, the neutralization being in all cases that of one molecule of sulphuric acid. The quantity of heat evolved amounts to 31134 as a mean, the single values differing almost $\frac{1}{2}$ of 1 per cent from this mean. Sulphuric acid evolves with other inorganic bases a less quantity of heat. Thus the heat of neutralization of PbO is 18750^c; that of Ag_2O 14040^c. The author infers from this result that the chemical character of the process of neutralization is different in different cases. Thus the first named eight bases do not evolve the same quantities of heat with one molecule of other acids. Thallium with chlorhydric and sulphydric acids behaves like silver, so that the numbers are nearly the same for the two metals. A solution of ammonia in water differs remarkably from the inorganic alkaline hydrates. Thus it gives with sulphuric acid only 28150^c, or 11 per cent less than the alkaline hydrates. On the other hand, tetra-methyl-ammonium-hydrate gives with one molecule of sulphuric acid 31010^c, or almost exactly the same number as the eight inorganic bases. Ethylamin gives nearly the same number as ammonia, namely, 28350^c. Triethyl-stibin-oxide, a divalent base, gave with sulphuric acid hardly 10 per cent of the heat of the alkaline and earthy bases, whence the author infers that it is a base of a wholly different character. From the above mentioned results, he considers it probable that an aqueous solution of ammonia does not contain a hydrate of ammonium, and that it is only an ammonium-base proper which is analogous to an alkaline hydrate. In conclusion, the author promises an investigation of the thermic relations of the organic bases. —*Berichte der Deutschen Chem. Gesellschaft, 4ter Jahrgang*, p. 308. W. G.

II. GEOLOGY AND NATURAL HISTORY.

1. *Currents of the Oceans.*—Mr. JAMES CROLL, in the Philosophical Magazine for 1870, volume xxxix, sustains the view that the currents of the oceans, including the Gulf Stream, are due to the action of the trade winds. Dr. W. B. Carpenter, in consideration of the results obtained by the deep ocean soundings has presented positive evidence that the ocean is stirred by its currents to its very bottom (this Journal, vol. xlix, p. 410, 1870), and claims, we think rightly, that the superficial action of the trades is not sufficient cause for the movement. An elaborate memoir by Dr. Carpenter "on the Gibraltar Current, the Gulf Stream and the General Oceanic Circulation," has been published during the current year by the Royal Geographical Society, from which we cite his conclusions, after stating the general principles on which he bases them.

A vertical circulation is maintained in the Strait of Gibraltar by the *excess of evaporation* in the Mediterranean over the amount of fresh water returned into its basin, which at the same time *lowers its level* and *increases its density ;* so that the *surface-inflow* of *salt* water which restores its level (exceeding by the weight of salt contained in it the weight of fresh water which has passed off by evaporation) disturbs the equilibrium and produces a *deep outflow*, which in its turn lowers the level.—The same may be assumed to be the case in the Strait of Babelmandeb.

A vertical circulation is maintained in the Baltic Sound by an *excess in the influx of fresh water* into the Baltic; which at the same time *raises its level* and *diminishes its density*, so as to produce a *surface outflow*, leaving the Baltic column the lighter of the two, so that a *deep inflow* must take place to restore the equilibrium.—The same may be assumed to be the case in the Bosphorus and Dardanelles.

A vertical circulation must, on the same principles, be maintained between polar and equatorial waters by the difference of their temperatures; the level of polar water being reduced, and its density increased, by the surface-*cold* to which it is subjected, while a downward motion is also imparted to each stratum successively exposed to it; and the level of equatorial water being raised, and its density diminished, by the surface-*heat* to which it is exposed. (The first of these agencies is by far the more effective, since it extends to the *whole depth* of the water, while the second effects, in any considerable degree, only the *superficial stratum.*) Thus a movement will be imparted to the upper stratum of oceanic water from the equator toward the poles, while a movement will be imparted to the deeper stratum from the Poles toward the equator.

Of such a *vertical circulation* in the general body of oceanic water we have evidence, on the one hand, in the *northerly* movement of the upper stratum, *of several hundred fathoms' depth*, which carries the temperature of a warmer region into the Arctic circle; while, conversely, there is now a large body of evidence as to the *general prevalence*, over the deep-sea bottom, of *a temperature not many degrees above the freezing-point of fresh water*, which cannot be accounted for in any other way than by an underflow of polar water toward the equator. Further, under particular circumstances, a yet greater degree of cold is brought by glacial currents into the Temperate zone: thus giving distinct indication of a general movement of deep water from the poles toward the equator.

Lastly, it follows, if the foregoing doctrine be correct, that the general *vertical* oceanic circulation is the great agent in moderating the extreme cold of the Arctic basin; the water which flows toward it being not so much propelled into it by the Gulf Stream, as drawn into it from an area of which the ordinary temperature is little, if at all, above the normal. On the other hand, the Gulf Stream forms part of a *horizontal* or *superficial* circulation in the

North Atlantic, of which the Trade Wind constitutes the *primum mobile:* a large part of its flow returns directly backward into the equatorial current, thus completing the *shorter* circulation; whilst the portion which passes northward ultimately returns in the *superficial polar currents* with which it interdigitates—one of these currents being sufficiently powerful to maintain a distinct course back to the exit of the Gulf Stream, where its deeper portion not improbably re-enters the Gulf of Mexico as a reverse under-current through the Narrows.

The view which Dr. Carpenter advocates, that the movement of the ocean affects the whole body of water to its very bottom, is recognized by the writer in his Report on Crustacea of the Wilkes Exploring Expedition, (4to, 1618 pp., 1852, this Journ., II, xvi, 1853), and the general system in this circulation is there pointed out,—this system according with the views previously held by the distinguished meteorologist, W. C. Redfield. The conclusions are sustained by facts relating to the temperature of the ocean observed in the course of the cruise of the Exploring Expedition just mentioned, and others from various sources, presented on an isothermal chart prepared for illustrating the geographical distribution of marine life, and especially the Crustacea; and a brief statement of this system is given in his Manual of Geology, (1861). The facts from the deep ocean remove all remaining doubt with regard to the universality of the movement, and the oneness of the system. At the same time there does not appear to be any good reason for separating from the system the Gulf Stream, as done by Dr. Carpenter. Given the vertical circulation, and the north and south movement, advocated by him, and then the revolution of the globe will make it, as has been long recognized, a *westward* movement in the tropics and an *eastward* in the middle and higher temperate latitudes, such as is found in fact in all oceans. Then, secondly, whenever, in the flow of these waters, they approach the continents, where the depth diminishes, the rate of flow will be increased in proportion (approximately) to the decrease of depth; and hence comes the stream east not only of North America and there called the Gulf Stream, but of South America, and also those east of Asia and of Australia; and also that in the higher latitudes west of South America. The Gulf Stream and all these other streams, are parts of the general system, modified by proximity to the continents; the action of the trades is not in any case their origination, though it may well be their accelerator. Neither is an Indian ocean current the origin of the current in the South Atlantic up the west side of Africa, though contributing to it.

Dr. Carpenter also combats Mr. Croll's position, with regard to the "thermal work of the Gulf Stream." J. D. D.

2. *On the "Benches," or Valley Terraces, of British Columbia;* by Matt. B. Begbie, Chief Justice of British Columbia.—The following extracts from this paper are selected from the Proceedings of the Roy. Geogr. Soc. for Feb. 27, 1871.—It is perhaps scarcely possible for any person who has never seen Fraser River, or ob-

tained an accurate description of it, if any verbal description can be accurate, to form an idea of its banks.

The distance from Lytton to Lilloett is 43 to 45 miles, and this may seem a considerable extent of bench formation when compared with Glen Roy, which extends but 20 miles. But the bench formation in British Columbia extends the whole distance of Fraser River so soon as the delta is left, as far as I have traveled up it, i. e. full 400 miles, and then the benches are seen running on, miles ahead. Wherever the formation has a chance of showing itself from Hope upward, i. e. wherever it is not interrupted by precipices, or chasms, or denudations, there are benches more or less clear and regular. Up the Quesnelle River, and on Cottonwood, an affluent of Fraser River next above Quesnelle, and Lightning, affluent of Cottonwood, up to within 25 miles of the Bald Mountain, the backbone of the Cariboo range, I still found exactly similar benches. The formation extends all up Thompson River, far above Kamloops, along both forks, as far as I could see. There are several well defined terraces on the Okanagan; in particular on the "Rivière du Sable," halfway down the lake, mounds like truncated pyramids, or rather a pile of four or five truncated sections of pyramids. On the only portion of the Columbia River which I have traveled, viz: Fort Shepherd to Fort Colville, the formation is just as distinct and striking as on Fraser River, and I am informed and fully believe that it is quite uninterrupted down to Snake River, in lat. 46°. The largest benches, both in length and breadth, that I have seen are in the valley of the Upper Kootenay River, about long. 115° 30′ W. (Lilloett being 122° W.). At Rock Creek, and all along Kettle River, the trails run for miles and miles along just such benches, and so too all along the Similkameen River and the Nicola River, not only at its influx into the Thomson, where there are six or eight heaped one upon top of another, but all along its course to the Nicola Lake. In fact, it may be said that everywhere in the Colony on the east side of Fraser River, wherever there is a river of any size, and the hills or mountains are near, but not too near, you find yourself on one of these benches, more or less regularly formed, but even when externally irregular, bearing traces of original regularity.

The benches are to all appearance in their normal state, level in the direction of the neighboring stream. But I suspect that they follow its general inclination—it might be said, incline "conformably" with the stream, as a general rule. For instance, it is very common for ditches—which, of course, always have some fall, though their fall varies extremely from an inch in a mile to an inch or more in a yard—to be carried along a bench in the direction of the principal stream, very rarely against that direction, and only when the supply is taken from a side creek, when, of course, the ditch may be taken in any direction. This question could not be determined without levelling a good many benches carefully. I should not be disposed to place much reliance on a barometer for such minute differences of level, and any hypsometer I have seen would be useless. But as to the transverse inclination (i. e. in the

direction at right angles to that inquired of by Mr. Robinson), a great many benches, especially as they recede from the river, have a very decided inclination, i. e. they slope from the mountain toward the stream, and sometimes very rapidly, as if an upheaving force had burst through a slightly flexible stratum of drift, and raised it to the highest point just before it finally emerged. Nevertheless the benches sometimes slope the reverse way; so that I know two or three instances of benches where lakes are formed next to the mountain base, the bench presenting an appearance similar to the "lip" on rivers running through alluvial flats, but which appearance is, I think, due to quite a different cause from the "lip," viz: to a local depression having taken place after the formation of the bench.

Just before reaching Lilloett, the benches become exceedingly striking. Speaking from memory, I should say there were at least five or six different benches, apparently as level, green, and well defined as billiard tables, on the east bank, and a still greater number on the west bank, or Lilloett side, where they are intersected in a most picturesque way by the brilliant N'Koomptch, running through the magnificent gorge leading from Seton Lake, about three miles from the Fraser, the northern extremity of the Douglass trail already referred to.

There are, I should say, speaking from memory, at and in sight of Lilloett, at least 15 or 16 benches on both sides at various levels, some three or four on each side of Fraser River exactly corresponding in level: but many on either side of the river having no apparently exact counterpart on the other bank. Lilloett stands on a plateau, which I judge to be about 160 feet above high-water mark of Fraser River, varying, between March and June, from 30 to 40 feet vertical. I have never been on the highest bench in this neighborhood, which I should say is on the east side, and which I should judge to be 500 or 600 feet above the Fraser.

There are, I should think, on the fort side (west bank of the river) at least twelve or fifteen terraces immediately at Alexandria; and from their regularity and contiguity—being generally narrow, and differing only a few feet in height—present a very singular and striking appearance: like a gigantic flight of steps ascending the hillside gradually.

The above are the more important facts presented by Mr. Begbie. From them he draws the conclusion that the "benches" or terraces are due to a vast lake, or series of lakes, and that this drainage was connected with an elevation affecting "a large mass of the continent," raising, at different periods, "various ridges of hills and mountains, either together or separately," and resulting in protruding them through the wide spread lacustrine formation.

3. *Note on River Terraces;* by J. D. Dana.—The first observations on the terraces of Oregon and California will be found in the Geological Report of the Wilkes' Exploring Expedition, by the writer, published in 1849, and in this Journal, 2nd ser., vol. vii, in which places the terraces or benches are attributed chiefly to river action. They are shown to be part of a system of terraces that

covers a large part of North America, north of the Ohio, and existing on all streams, as far as examined, nearly to their heads in the mountains, as stated above to be the fact with those along some streams on the Pacific border. It is there remarked that if admitted to be lake terraces, the facts would prove that a large part of the continent had been covered with lakes in place of rivers, and just where rivers should have existed, which is a view not to be entertained.

The lower flats or flood grounds now existing along any stream follow it to its head, with interruptions depending on the width of the valley and nature of the enclosing deposits (whether hard rock or not); and thus such flats, while the sea has its present level, may exist on a single river at all heights, from a few feet above the sea level to the height approximately of its source, or through a range of level it may be of thousands of feet. Such flood grounds are approximately parallel to the adjacent bed of the stream, the variations depending largely on obstructions in the course of the stream and being such very nearly as actually exist between flood level and low-water level.

If now a part of the continent be raised 50 feet, the abrading or excavating force of the streams would be increased; the low-water channel would be accordingly deepened by abrasion, and a new flood ground or lower flat would also be produced with the old flood ground as a terrace or bench. The height of this terrace or bench would depend on the depth of the river excavation; and this on the nature of the bottom, etc.; thus with a single elevation of 50 feet, terraces may be made at all heights above the sea from 50 feet to 5000 or more, according to the height of the head-waters of the rivers. This fact is of the highest geological importance; very many errors as to evidences of changes of level have been made from a failure to consider it. Moreover, more terrace levels than one might be formed on this single sudden rise of the land wherever there were obstructions that were afterward successively removed. Such obstructions might in some parts of a stream make lakes, and cause true horizontal benches for an interval. Thus the terraces or benches along streams may be accounted for without recourse to lakes except those that would be incidental to such a system of river changes. They are evidences that the stream has excavated its bed to a lower level than that which it formerly had; and the proof as to change of level indicated is to be derived not from an isolated fact in any place, but from a general survey of all the facts throughout a great region—facts as to heights of terraces, as to excavating force of stream in its different parts, and as to possible obstructions that have put a limit to excavation or occasioned intervals of retardation.

4. *Glaciers.*—The Philosophical Magazine for June, (pp. 485–508) contains a translation of a valuable paper on Glaciers from Poggendorff's Annalen, by ALBERT HEIM of Zurich. The following paragraphs are from pages 495, 496.

M. Grad ascribes to the freezing of the infiltrated water in the capillary fissures, not only the enlargement, but also the "crystallographic orientation" of glacier-ice, discovered by Bertin, and afterwards confirmed and generalized by MM. Grad and Dupré. But he seems to me to form no accurate conception of how this is to be produced by the water freezing round the surface of the grains. It might be very difficult to do so. I am inclined rather to look upon the "crystallographic orientation" as a function of the pressure. The ice masses of the lower part of the glacier, in which it has been observed, are not the same which in the upper part did not exhibit the phenomenon; they are those which, during many years, have sustained the mighty pressure of the overlying layers of ice, now melted away. When we consider that, in a body the temperature of which is always near its melting-point, molecular derangements readily take place, and that there is no lack of shocks which go through the mass of ice (such as occurs, for example, in the crash whenever a crevasse opens or closes), the latter notion becomes still more probable. The phenomenon observed by MM. Bertin, Grad, and Dupré, that in lamellæ cut horizontally out of the lower part of the glacier colored rings with a black cross are seen when they are viewed in the polarizing microscope, does not necessarily indicate actual crystalline structure; amorphous glass can yield the same phenomenon through strains forced upon it by external pressure. It appears to me that the effect in the glass also would necessarily be permanent, if the violent pressure had operated for many years. Experiments on a small scale, for the purpose of producing by pressure the crystallographic orientation in pieces of ice, gave no result. This is not surprising; for I could not, as many a glacier does, operate with a pressure of 5 cwt. per square inch, or factors of similar magnitude. Already in the 27th volume of the Philosophical Magazine Sir John Herschel conjectured a parallel arrangement of the optic axes, but not on grounds corresponding with M. Grad's explanation.

I must not, however, omit to mention that, according to the calculations of an Englishman (Canon Moseley) in the Philosophical Magazine for May, 1869, the resistance of the ice to the shearing-forces of the glacier-motion would be too great for the ice to be broken by gravity alone and thus the glacier to move by its own weight. If I rightly understand the experiments of Tyndall and my own on the remoulding of plates of ice, the ice therein and in the glacier is not compelled to shear, but to break by the bending. The shearing, tangential displacements take place along the fissures previously produced by fracture (bending). The very peculiar mechanical conditions of the ice seem to me not to have been sufficiently considered in the calculation. One of these is its extraordinary brittleness even at 0° C.; the same pressure which a mass of ice will sustain in a state of rest for a long time without breaking, breaks it immediately if a shock is added. Another is the occurrence of crowds of minute air-bubbles, which must very

much diminish the compactness of the ice. In the lower part of a glacier, where air-bubbles are almost absent, we have the old, only half regelated secondary capillary fissures, along which fresh fracture is easier: while in this region the primary fissures are somewhat less numerous, the secondary (which are longer preserved) exhibit a peculiar abundance of plaits. So many factors, unmeasured in their effect and scarcely known in their mode of operation, are involved in the mechanics of glacier-motion, that the result of a calculation based on the little that is known cannot possibly induce me antecedently to reject the explanation by pressure, with which all the facts of which I have any knowledge, and all that I have seen, agree so perfectly. According to the explanation of glacier-motion given by Mr. Moseley (Phil. Mag., Jan. 1863 and Aug. 1869), the total motion must be, on the average, equal in amount in the upper, middle, and lower parts of the glacier, which is not the case. As in no part of the glacier, certainly not at the lower end, has any (even the least) upward motion ever been observed at certain times, the line which, as a base, remains relatively fixed must, when the temperature falls, lie at the upper end of the glacier; when the temperature rises, at the lowest point. That with rise of temperature the lower end would remain stationary, and drag after it the whole long glacier-tongue (which cannot descend by its own weight), without its being rent transversely into single independent fragments, I cannot conceive. The surface of the glacier undergoes more and greater variations of temperature near its margins than in the center—now from reflection of heat from the sides of the valley, then from their shade, but especially through the winds (which in the center arrive with their temperature already approximated to that of the glacier). The margins have in some measure a more continental, the center a more oceanic climate. Hence one would think that the edges of the glacier would move faster than, or at least as fast as the center, if variations of temperature effected the motion.

I have not the remotest intention to summarily reject Mr. Moseley's views; but I thought it admissible to state what at present appears to me opposed to them, in order to justify my continuing to hold Professor Tyndall's explanation. Perhaps Mr. Moseley will be able to remove these difficulties and, especially by measurements of the interior temperature of glaciers, give his views a better foundation.

5. *On Sigillaria, Calamites and Calamodendron.*—Dr. J. W. Dawson, in the Q. J. Geol. Soc. for May, 1871, discusses the nature of these fossil plants and presents many facts of his observation. The tissues of the Sigillariæ, and the character of the fruits (*Trigonocarpum* and *Cardiocarpum*) which very often accompany the trees, are regarded as proving that they are true Gymnosperms or are related to the Conifers and Cycads. But he further remarks that possibly the group may have included forms bridging over the interval between the higher Acrogens (the Calamites on one side and the Lepidodendron on the other) and

the Gymnosperms. The *Calamites*, according to Dr. Dawson, are true Equisetaceous plants, and the fossils exhibit the exterior surface of the stems. But other fossils marked externally like Calamites are casts of the pith or *internal axis*, and belong to the genus *Calamodendron*. The Calamodendra often have a considerable thickness of woody envelop about the apparently jointed internal axis, consisting of woody tissue in wedges separated by intervening tracts of cellular tissue (medullary rays according to Williamson); and they are therefore classed by Dr. Dawson with Gymnosperms.

Dr. Dawson makes the line from Sigillaria to Lepidodendron to include, in order, *Lepidophloios*, *Syringodendron*, *Clathraria*, *Favularia?*, *Rhytidolepis*; and the line from *Sigillaria* to *Equisetum* to include *Calamodendron Calamopitus* (of Williamson), *Bornia*, *Calamites*.

6. *Lepidodendra and Sigillariæ.*—In a paper read before the Royal Society, June 15, Prof. W. C. Williamson describes the structure of specimens of *Lepidodendra selaginoides*, and appears to make good the conclusion that it has an imperfect exogenous structure. He observes that it has a central medullary axis, which is closely surrounded by a second and narrower ring also of barred vessels, but of smaller size, and arranged in vertical radiating laminæ "which are separated by short vertical piles of cells believed to be medullary rays. In a transverse section the intersected mouths of the vessels form radiating lines," and the structure is pronounced an early type of an exogenous cylinder. From this cylinder alone the vascular bundles going to the leaves are given off.

He describes *Stigmaria* ("well-known," he says, "to be a root of Sigillaria,") as having "a cellular pith without any trace of a distinct outer zone of medullary vessels such as is universal amongst the *Lepidodendra*. The pith is immediately surrounded by a thick and well-developed ligneous cylinder, which contains two distinct sets of primary and secondary medullary rays." Other facts stated tend to show that these plants are of the Lepidodendroid type, and Prof. Williamson therefore includes the *Lepidodendroid* and *Sigillarian* plants in a common family, making them, along with the *Calamiteæ*, to constitute an *Exogenous* division of the vascular Cryptogams, while the *Ferns* belong to an *Endogenous* division, "the former uniting the Cryptogams with the Exogens, through the Cycadeæ and other Gymnosperms; and the latter linking them with the Endogens through the Palmaceæ.

7. *Helderberg Corals in New Hampshire.*—Prof. C. H. Hitchcock, State Geologist of New Hampshire, announces the discovery of Helderberg corals in Littleton, N. H. New Hampshire has been considered an Azoic State by some, as its rocks are mostly of a granitic character. Professors H. D. and W. B. Rogers supposed at one time they had found Silurian fossils in the White Mountain Notch, but afterward withdrew the opinion.

The limestone containing these corals has been traced for about three miles, and appears to be duplicated by a synclinal fold. It overlies the metamorphic Quebec group on one side, and probably the Coös group on the other. It appears to be overlaid by a clay slate carrying a few worm-trails.

The corals themselves are obscure. They have been submitted to the examination of E. Billings, F.G.S., of Montreal. He recognizes the *Favosites basaltica*, and a *Zaphrentis*. The rock appears to be identical with that cropping out upon lake Memphremagog and its supposed continuation into Vermont. The New Hampshire locality is fifty-five miles southeasterly from the Canadian. As the associated rocks are somewhat similar, it is likely that the two limestones are of the same age. Mr. Billings does not speak positively of the distinctive age of the Canadian limestone. It seems to range from the Lower to the Upper Helderberg. He compares it with the Gaspé limestone, which corresponds with the entire Helderberg series of New York. A fossil from Owl's Head, shown to Professor Hall by the writer several years since, was declared to be the peculiar *Atrypa reticularis* of the Upper Helderberg. With our present information it is only possible to say that Helderberg fossils have been found in New Hampshire. C. H. H.

8. *On Fossil Coal plants from the Altai;* by Dr. H. B. Geinitz. (From Cotta's "Der Altai," in course of publication).—The coal plants here noticed were brought by Dr. Cotta from the Museum of Barnaoul. They are mostly of described species already recognized there by Eichwald and others. The species remarked upon are *Equisitites Socolowski* Eichwald, *Anarthrocanna deliquescens* Göpp., *Cyatheites Miltoni* Artis, *Annularia longifolia* Brgt., *Cyclopteris orbicularis* Brgt., *Sphenopteris anthriscifolia* Göpp., *Lepidodendron Serlii* Brgt.; a *Pterophyllum* near *Pt. inflexum* Eichw. (on same specimen with *Annularia longifolia*); *Trigonocarpus acteonelloides* Gein., *Nœggerathia æqualis* Göpp., *N. palmæformis* Göpp.; *N. distans* Göpp.; *Araucarites Tchithatcheffianus* Göpp.—Geinitz mentions the fact of the occurrence of a Cycad, *Pterophyllum blechnoides* of Sandberger, in the Carboniferous beds of the Baden Schwarzwald, to show that the Siberian species is not a solitary case. The memoir is illustrated by three lithographic plates. Dr. Geinitz remarks in closing that the species are not Permian, and that they belong to the later Carboniferous.

9. *Preliminary Report on the Vertebrata discovered in the Port Kennedy Bone Cave;* by Prof. E. D. Cope, (Proc. Am. Phil. Soc., April 7, 1871).—This paper, mention of which is made in vol. i, on page 384, of this Journal, (May, 1871), contains descriptions of 5 species of Megalonyx, *M. loxodon*, *M. Wheatleyi*, *M. dissimilis* Leidy, *M. sphenodon*, *M. tortulus*, *Mylodon? Harlani*, *Sciurus calycinus* Cope, *Jaculus? Hudsonius* Zimm., *Hesperomys* ——?, *Arvicola speothen* Cope, *A. tetradelta* id., *A. didelta* id., *A. involuta* id., *A. sigmodus* id.; *A. hiatidens* id.; *Erethizon cloacinum*

id.; *Lepus sylvaticus* Bachm.; *Praotherium* (a genus near *Lepus*, Cope) *palatinum*; *Scalops* ——?; ? *Vespertilio* ——; *Mastodon Americanus*; *Tapirus Americanus*; *T. Haysii* Leidy; *Equus* ——?; *Bos* ——?; *Ursus pristinus* Leidy; *Felis* ——? In all there are 34 species, and 72 individuals. Of them, 11 are American tropical forms, 3 North American Arctic, 11 are common to both hemispheres; and 9 are of uncertain regional relations. Prof. Cope concludes with a discussion of the relation of the species to the earlier American fauna, the geographical and other changes of the Post-tertiary, and the origin of the cave.

10. *Winkworthite*; Prof. How.—Winkworthite is a borate occurring in nodules in the gypsum quarry at Winkworth, Hants Co., Nova Scotia. It forms nodules, as large as a walnut. A surface of fracture was flat, and was covered with glistening irregular facets, and scrapings showed under the microscope transparent oblique-angled plates. H. = 3, but of outside 2. In the closed tube yields water and becomes opaque. B.B. decrepitates and fuses easily to a clear bead, giving a bright green flame; in continued blowing, froths, the bead becomes opaque and the flame loses its green color. Analysis afforded Sulphuric acid 36·10, silica 3·31, boracic acid by loss 10·13, lime 31·66, water 18·80, which composition affords the atomic proportions $9\ddot{S}$, $\dot{S}i$, $3\ddot{B}$. $11\dot{C}a$, $20\dot{H}$.

Another nodule afforded $\ddot{S}$ 31·51. $\dot{S}i$ 4·98, $\ddot{B}$ by loss, 14·37, $\dot{C}a$ 31·14, $\dot{H}$ 18·00, whence the ratio, $8\ddot{S}$, $\dot{S}i$, $4\ddot{B}$. $11\dot{C}a$, $20\dot{H}$.

Ulexite has been found in Nova Scotia, in gypsum, at Clifton Quarry, Windsor; Brookville; Trecothick's Quarry; Three Mile Plains; Winkworth; Newport Station. *Cryptomorphite*, in Glauber salt in gypsum at Clinton Quarry. *Howlite*, in gypsum and anhydrite at Brookville, and in gypsum at Winkworth, Newport Station, and Noel.—*Phil. Mag.*, April, 1871.

11. *Trinkerite.*—A fossil resin, described by Tschermak, containing over 4 p. c. of sulphur, from an Eocene coal bed, at Carpano in Istria. This sulphur-bearing resin has been observed also, by T. Niedzwiedski, at Gams, near Hieflau in Styria, imbedded in a dark colored rock of the Upper Cretaceous formation.—*Bulletin of the K. Akad. Wien. Nature*, No. 87.

12. *Arrangement for Cross fertilization of the flowers of Scrophularia nodosa.*—It is probable that the dichogamy of the flowers of *Scrophularia* has already been observed and published; but it was new to me until pointed out this season by my assistant, Dr. Farlow. The arrangement is thus: In the freshly opened blossom the upper part of the style is bent forward so as to bring the stigma now ready for pollen, just over the patent lower lip of the corolla: the anthers, not yet dehiscent, are out of sight toward the bottom of the corolla, the filaments being strongly recurved or doubled over. In the blossom a day or two older, the stigma has dried up, the style become flabby; and the filaments have straightened so as to bring the four anthers up to the gorge of the corolla at the base of the lower lip, just back of the now withering stigma; the transversely dehiscent anthers are now widely open. The

flowers are visited by honey-bees, which barely insert their heads into the gorge of the flowers; the chin or throat of the bee, coming into contact with the lower lip of the corolla, is necessarily dusted with pollen from the older flowers; and this pollen, in the passage from flower to flower, and plant to plant, is inevitably applied to the stigma of the freshly opened flowers, which alone is in condition to receive it. The nectar sought by insects is here secreted abundantly by the corolla, at its base on the posterior side, and to some extent by the disk which girts the base of the ovary; the posterior face of the scale which represents the anther of the fifth stamen is apparently glandular, but hardly if at all nectariferous. Bees plunge their proboscis to the bottom of the flower. A. G.

13. *Transmutation of Form in certain Protozoa.*—Mr. Metcalfe Johnson has a paper on this subject, in the number for May, (No. 29), of the Monthly Microscopical Journal, (London), presenting views similar in some respects to those of Mr. Hilgard, (pages 20 and 88, of this volume). The following passages from the article present the general conclusion of the author.

In the 'Monthly Microscopical Journal' for April, 1870, I have ventured to remark that "Monas and its congeners become at once important as agents in removing dead cells, and in their place supplying us with *green* verdure which is springing up around us on every side." Everyone must have observed that universal greenness which, after the lapse of a few weeks, spreads more or less over every weather-exposed surface, large or small. Sir Humphrey Davy, writing forty years ago, says, "A polished surface of a building or a statue is no sooner rough than the seeds of lichens and mosses which are constantly floating in the atmosphere make it a place of repose, grow and increase." If we examine a few of the green growths upon these surfaces differing from one another in their surroundings, or "choses extérieures," such as moisture, light, temperature, &c., we shall find one composed of a green dust, to which the name of *Chlorococcus* has been applied; another, a green scum upon the surface of a liquid, which has received the name of *Euglena;* a third, forming patches of dark green slime upon old walls, and called *Oscillatoria;* a fourth, *Lyngbya;* a fifth, *Vaucheria;* a sixth, *Schidzonema*, and so on. A more detailed examination of these separately-named products, and a study of their life-history, leads to the opinion that they are all (more or less) stages of development of some one common source, which it is the object of the present remarks to identify as the monad, or pin-point, source of life, which has been pointed out by Dr. Bastian and others as the earliest form in which we recognize living matter.

In order to commence this investigation I will append a few observations I have made on various forms of *Paramœcium*, and I shall endeavor to show that it constantly transforms to *Vorticella*, and thence passes to *Callidina elegans*, thus tracing one of the phases of growth by development from the simple form of *Monas* to some of the more complicated animalculæ or Entomostraca. I

shall hope in a future communication not only to trace the *Paramœcium* from the monad, but also to show that the "choses extérieures" being altered the monad may become a *Chlorococcus*, an *Oscillatoria*, a *Lyngbya*, a moss, a lichen, an *Amœba*, or a *Mucedo*.

14. *Embryological Studies on Diplax, Perithemis, and the Thysanurous genus Isostoma;* by A. S. PACKARD, Jr. Memoirs of the Peabody Academy of Science, Volume I, Number 2. Salem, Mass., March, 1871.—This memoir contains quite full and interesting descriptions of the development of the embryos of *Diplax* and *Isostoma*, with a few observations on *Perithemis*. "An interesting point in the embryology of *Isostoma* is the homology of the spring. Though its earliest development was not observed, it is evidently homologous with the third pair of blades comprising the unjointed ovipositor of the higher insects, and seems to be homologous with the legs and cephalic appendages." Dr. Packard also suggests that the three pairs of processes ordinarily forming the ovipositor of insects are homologous with the abdominal legs of myriapods and the spinnerets of spiders. He also concludes that the eyes and ocelli of insects do not represent limbs and that they arise on segments bearing other appendages, and, therefore, the head of insects may be considered as composed of but four segments. This memoir is illustrated by two plates and several wood-cuts. v.

15. *Seaside Studies in Natural History;* by ELIZABETH C. AGASSIZ and ALEXANDER AGASSIZ. Second edition, 1871. (James R. Osgood & Co., Boston).—This is one of the few books on Natural History which combine scientific accuracy with a popular treatment of the subject. It is, moreover, the only popular work in which many of the most interesting marine animals of our shores are described and figured. It is, therefore, gratifying to see that the work has been so well appreciated as to require a second edition. In this edition but few changes have been introduced. These are chiefly in the chapter on the distribution of marine life. A list of the wood-cuts and an explanation of the abbreviations of authors' names have been added. v.

16. *Report on the Brachiopoda obtained by the U. S. Coast Survey Expedition, in charge of L. F. De Pourtales, with a Revision of the Craniidæ and Discinidæ;* by W. H. DALL.—Bulletin of the Museum of Comparative Zoology, Vol. iii, No. 1, Cambridge, Mass.—In this paper all the species dredged by Mr. Pourtales are fully described, and the synonymy of these and other species and genera is well worked out. The anatomy of several of the species is described at considerable length. Two lithographic plates, chiefly anatomical, illustrate this paper. v.

17. *Arrangement of the Families of Mollusks;* by THEODORE GILL. Smithsonian Miscellaneous Collections, February, 1871.—In view of the wide diversity of opinion among zoölogists concerning the classification of Mollusca, it is not to be expected that any scheme that can be proposed at present will be generally adopted. Yet we are constantly approximating to a true natural classification of these animals, thanks to the numerous anatomical investigations that have recently been undertaken. The author of the

present work fully acknowledges the provisional character of the arrangement which he has adopted, and anticipates many changes hereafter. In reality, some improvements made within the past year would doubtless have been adopted, had not the work been in type some six months before its actual publication. It is, nevertheless, the best index to the classification of the Mollusca that has been published hitherto. It gives in a very convenient form an arrangement in accordance with the views of many of the most reliable malacologists. It is probable that in numerous cases too many families have been admitted, or divisions of minor value have been allowed family rank. This appears to be especially true for the Nudibranchs, where the classification of Dr. Gray has been followed. But such imperfections are of comparatively small importance in view of the uses for which this "arrangement" is intended. It is accompanied by a useful list of authors and an alphabetical index to the names of the classes, orders, and families. Mr. Gill admits 27 orders and 356 families. v.

18. *Supplement to the Synopsis of the Extinct Batrachia and Reptilia of North America;* by E. D. Cope (Proc. Am. Phil. Soc., March 3, 1871.)—This paper contains notices of *Sauropleura remex* Cope, *Oestocephalus amphiuminus* id., *Colosteus scutellatus* Newb. (Proc. Ac. N. Sc. Philad., 1856); *Liodon sectorius* Cope (a Mosasauroid from the N. Jersey Cretaceous); *Zygorapha microglypha* id., (of the family Adocidæ) from the New Jersey Cretaceous; *Catapleura ponderosa* Cope, Cretaceous of N. Jersey; the Crocodilian, *Bottosaurus macrorhynchus* Harlan, from the upper bed of Cretaceous Green Sand of New Jersey (the *Croc. basitruncatus* Owen, in Cope's Syn., p. 65, a species of *Holops*, on p. 231); the Dinosaur, *Hadrosaurus cavatus* Cope, from same locality, a species of gigantic size.

19. *Animals of Sponges.*—Mr. H. J. Carter, whose researches on Sponges, confirming the observations of Prof. H. James-Clark, are briefly noticed on page 70, has an extended article on the subject in the Annals and Magazine of Natural History, for July, 1871 (IV, viii, 1), illustrated by two plates.

20. *On the Homologies of some of the Cranial bones of the Reptilia, and on the systematic arrangement of the class;* by E. D. Cope. (Proc. Amer. Acad., xix, 194–247.)

III. Miscellaneous Scientific Intelligence.

1. *Note to the Article on a new attachment to the Lantern, on page* 71. From a letter to the Editors dated, Hoboken, N. J., July 8, 1871.—I have just noticed the description of my vertical lantern which you have been kind enough to publish in your July issue, and find that through some inadvertence, a credit has been omitted which I have been careful to give on all occasions.

To Prof. J. P. Cooke of Cambridge belongs the credit of first constructing a lantern to exhibit horizontal objects by first reflecting the light from the condensers upward by a mirror and then again turning the rays to the screen by a silver speculum.

Prof. Cooke kindly showed me this apparatus in operation last summer, and in the instrument which you have described I have simply improved upon his plan with reference to the mechanical arrangement, and, by interposing the first mirror between the elements of the condenser by which I have secured an evenly illuminated and uncolored field of light upon the screen, and by finding that an ordinary glass mirror silvered on the rear surface would answer perfectly well for the final reflection.

To Prof. Cooke is likewise due the idea of thus showing the waves in a tank of water circular or elliptical.

To the experiments already mentioned I have lately added a new one of unusual beauty. By clamping a large square glass Chladni plate so that one corner covers the lantern field, and covering this corner $\frac{1}{8}$ inch deep with water retained by a light ring of rubber, the most beautiful patterns of crispations changing with the change of tone given by the plate can be shown on the screen.

Yours, &c. HENRY MORTON.

2. *Note to the Article on the application of Photography to the determination of Astronomical data;* by ASAPH HALL.—Mr. David Trowbridge of Waterburgh, New York, has called my attention to the fact that Professor Bartlett of West Point, had applied the photographic method to determine the times of contact in a solar eclipse as early as 1854. Professor Bartlett's observations were published in Gould's Astronomical Journal, vol. iv, p. 33.

A. H.

3. *On the Color of Fluorescent Solutions;* by HENRY MORTON, Ph.D.—We have from Dr. Morton a paper for the next number of this Journal describing experiments of his which sustain the interesting conclusion that "all the familiar fluorescent solutions, such as the tincture of Turmeric, of Agaric, of Chlorophyl, and the solution of Nitrate of Uranium, emit lights of the same color of fluorescence—namely, blue, identical with that developed by acid salts of quinine.

4. *Indianapolis Meeting of the American Association for the Advancement of Science, Aug.* 16, 1871.—According to a circular issued by the Local Committee, the first session will be held at the Academy of Music at 10 o'clock A. M., when a reception will be extended to them by his Excellency, Conrad Baker, Governor of Indiana.

Members, and those who wish to become members, are requested, immediately upon their arrival, to register their names at the office of the Local Committee, at the State House, where they will be furnished with member's tickets, and such information as may be desired in regard to accommodations, etc. The citizens have signified their desire to extend hospitality to the members. There are likewise ample hotel accommodations, and special arrangements will be made with hotel and boarding house proprietors for reduced rates. It is therefore particularly requested that persons intending to be present, will notify the Local Secretary (Prof. E. T. Cox) by letter, as early as practicable, and when possible, state the day they will arrive.

Jahresbericht über die Fortschritte der Chemie, etc. Unter Mitwirkung von A. Laubenheimer, Al Naumann, F. Nies, F. Rose, herausgegeben von Adolph Strecker. Für 1869. Erstes Heft. Giessen, 1871.